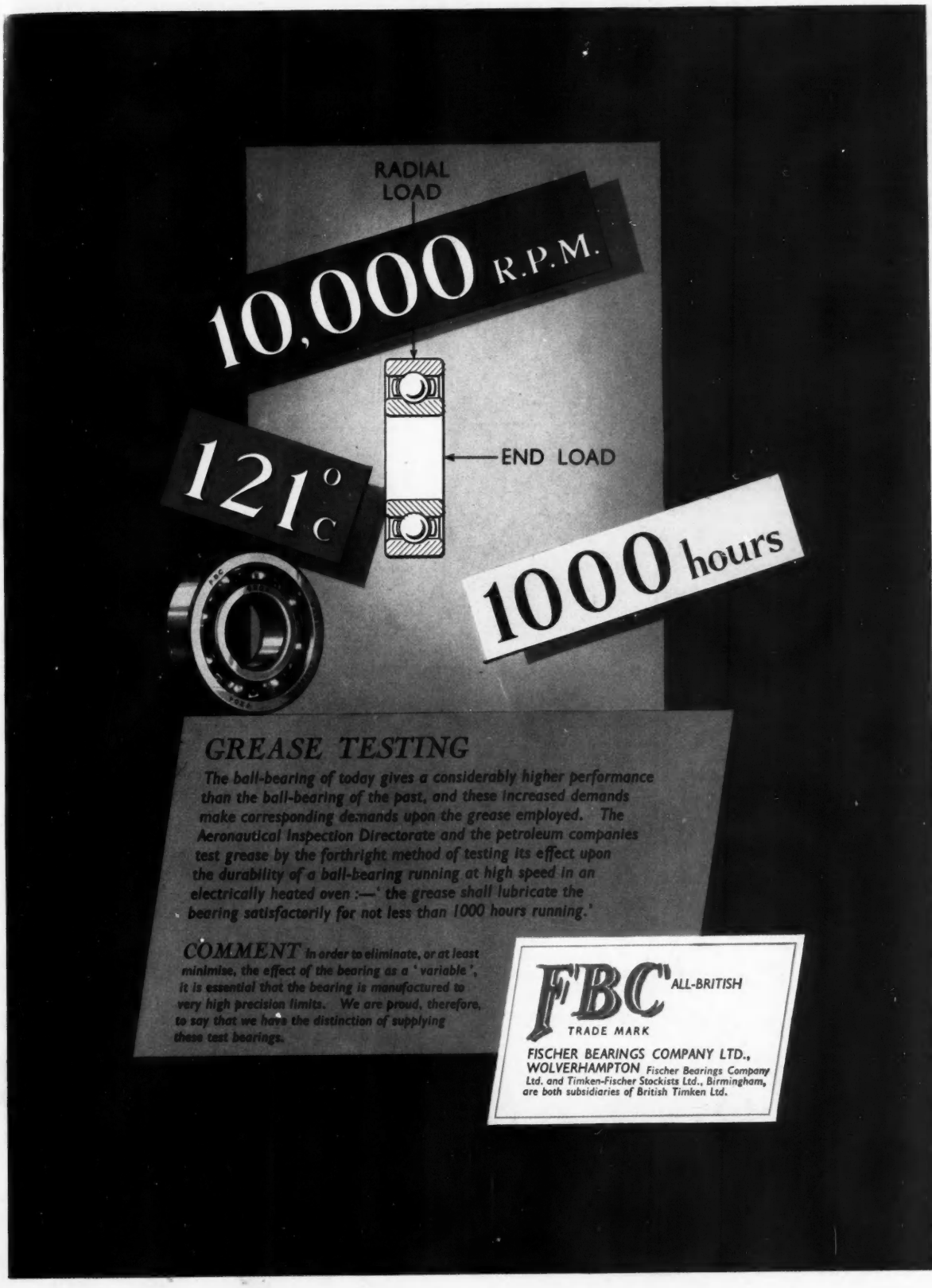
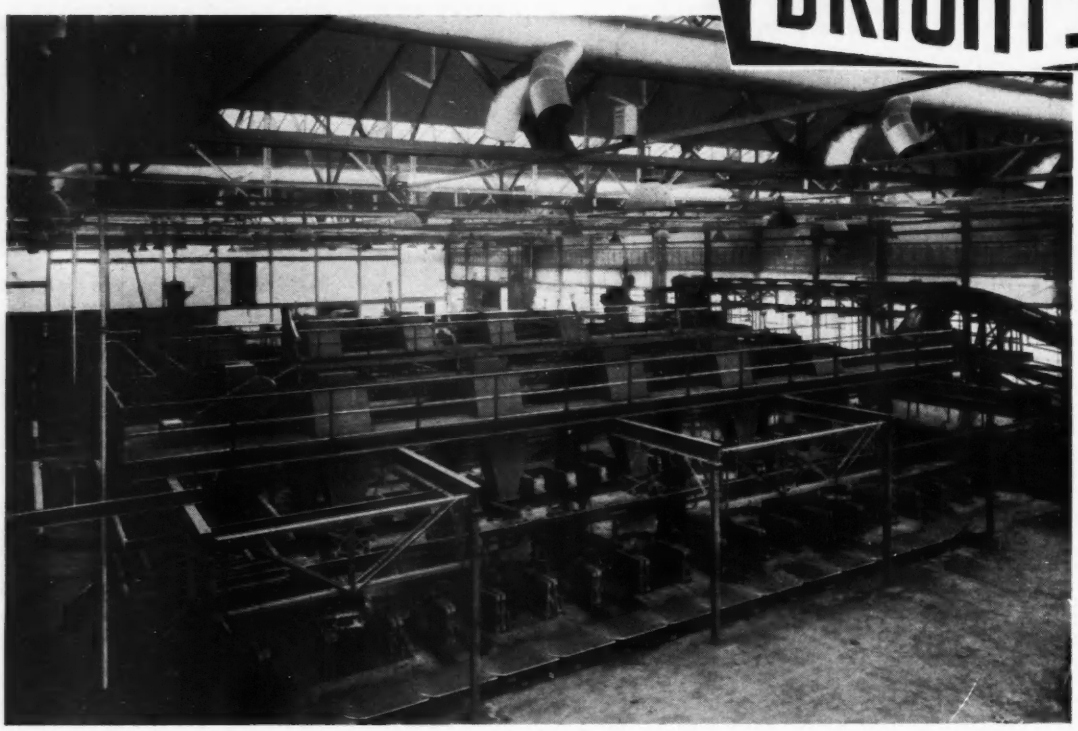
The Engineer

JANUARY 23, 1953 — 28, ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

UNIV. OF MICHIGAN
FEB 12 1953
ENGINEERING LIBRARY


RADIAL LOAD
10,000 R.P.M.
121° C
END LOAD
1000 hours
GREASE TESTING
The ball-bearing of today gives a considerably higher performance than the ball-bearing of the past, and these increased demands make corresponding demands upon the grease employed. The Aeronautical Inspection Directorate and the petroleum companies test grease by the forthright method of testing its effect upon the durability of a ball-bearing running at high speed in an electrically heated oven :— ' the grease shall lubricate the bearing satisfactorily for not less than 1000 hours running.'
COMMENT In order to eliminate, or at least minimise, the effect of the bearing as a ' variable ', it is essential that the bearing is manufactured to very high precision limits. We are proud, therefore, to say that we have the distinction of supplying these test bearings.
FBC ALL-BRITISH
TRADE MARK
FISCHER BEARINGS COMPANY LTD., WOLVERHAMPTON Fischer Bearings Company Ltd. and Timken-Fischer Stockists Ltd., Birmingham, are both subsidiaries of British Timken Ltd.

Plenum heating by BRIGHTSIDE



Brightside Plenum Heating in a modern mechanised foundry; the vitiated air is extracted and replaced by warm clean air. The smaller illustration shows a plenum installation in a machine shop.

Where ventilation is a dominant consideration, it is often most economical to combine ventilation with heating in a common system of Plenum Heating. The flow of air into the rooms is controlled both as to quantity and temperature; in some cases partial recirculation is permissible. Such installations are well adapted to buildings with high-density occupancy.

Write for our booklet :—
HEATING AND AIR TREATMENT IN INDUSTRY

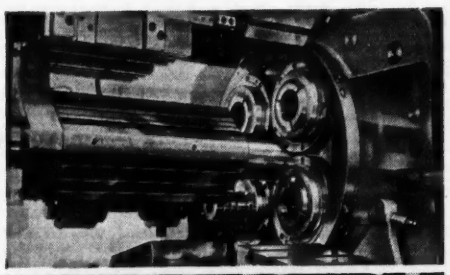
THE BRIGHTSIDE FOUNDRY & ENGINEERING CO. LTD. SHEFFIELD

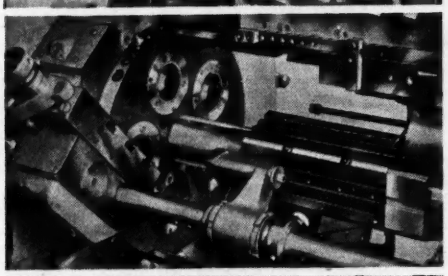
and at BIRMINGHAM BRADFORD BRISTOL LIVERPOOL LONDON MANCHESTER
NEWCASTLE PORTSMOUTH EDINBURGH GLASGOW BELFAST

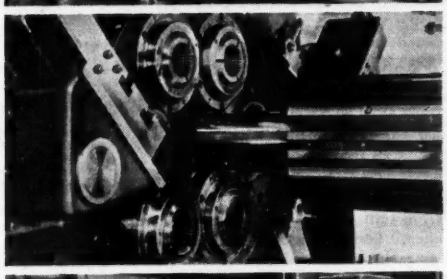
BP 24a

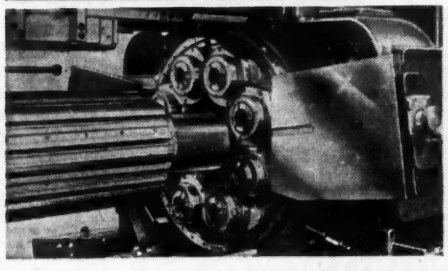
Wickman

FOUR, FIVE, SIX
EIGHT SPINDLE AUTOMATICS
provide production engineers with new opportunities to increase output and lower costs

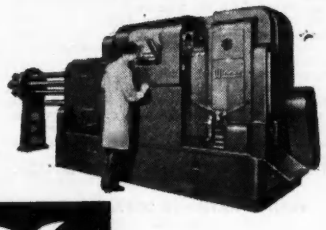

4 SPINDLES 3½" bar capacity


5 SPINDLES ⅞", 1⅜", 1¾" or 2¼" bar capacity


6 SPINDLES 2⅜" bar capacity


8 SPINDLES 1¾" bar capacity

Fast producing Wickman Multi-spindle Automatics can now be applied to a wider range of jobs than ever before. The Wickman patent auto-setting mechanism is incorporated in all machines of the range and alterations to tool feed strokes and bar feed are accomplished without cam changing.



Wickman

WICKMAN of COVENTRY

WM280

THE ENGINEER

ESTABLISHED 1856

Vol. 195 No. 5061

JANUARY 23, 1953

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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LINEAGE RATE (Under 1 inch):—2s. 6d. per line of 6 words. Minimum 10s.

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USE OF BOX NUMBER: The charge is 2s. including the cost of re-addressing replies, which are forwarded immediately on receipt. N.B. There is no Charge for Box Nos. under "Situations Wanted."

WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF BRISTOL

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURER (GRADE II OR GRADE III)

Applications are invited for a post as LECTURER (Grade II or Grade III) in the Department of Mechanical Engineering, at an initial salary within the range of £400–£900 per annum, according to qualifications and experience, with F.S.S.U. benefits and family allowances. Applicants should have good academic qualifications and practical experience. Further particulars may be obtained on request, and applications, including the names of two persons to whom reference may be made, should be sent within two weeks of the appearance of this advertisement to the Registrar, The University, Bristol, 8. E7045

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF CIVIL ENGINEERING

ASSISTANT LECTURER OR LECTURER

Applications are invited for the post of ASSISTANT LECTURER or LECTURER in the Department of Civil Engineering. The initial salary for an Assistant Lecturer will be £450 per annum with allowance for age, experience and qualifications ; the initial salary for a Lecturer will be within the range £550–£800 per annum, according to qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 23rd February, 1953, by the undersigned, from whom further particulars of the conditions of appointment may be obtained.

STANLEY DUMBELL,
Registrar.

January, 1953. E6993

LONDON COUNTY COUNCIL

ROBERT BLAIR FELLOWSHIP IN APPLIED SCIENCE AND TECHNOLOGY

London County Council invites applications for the ROBERT BLAIR FELLOWSHIP, tenable for one year, for advance study or research in applied science and technology abroad. Value of the award (originally £450) is variable, may be about £900 if Canada or U.S.A. selected, and is subject to P.A.Y.E. Candidates must be British subjects and at least 21 years old.

For application form and further particulars send stamped, addressed foolscap envelope to Education Officer (EO/H1/2), County Hall, S.E.1. Apply by 2nd March, 1953. (1311) E6987

BOROUGH OF HARROGATE

APPOINTMENT OF WATER ENGINEER AND MANAGER

Applications are invited from fully qualified civil engineers for the position of ENGINEER and MANAGER of the water undertaking.

Only civil engineers having practical experience of the design and construction of civil engineering works for water supply, and experience in the maintenance and management of a waterworks undertaking will be considered.

The commencing salary for the position will be £1250, rising (subject to satisfactory service) by annual increments of £50 to £1450 per annum.

The recommendations of the Joint Committee for Water Engineers Salaries and the Joint Negotiating Committee for Chief Officers of Local Authorities as to Conditions of Service will apply to the appointment.

The appointment will be subject to the provisions of the Local Government Superannuation Act, 1937, and to termination by three months' notice in writing on either side.

The successful candidate will be required to pass a medical examination.

Applications, endorsed "Water Engineer and Manager," giving particulars of age, qualifications and experience, with the names and addresses of three referees, must reach me not later than 16th February, 1953.

Canvassing will disqualify and applicants must state whether, to their knowledge, they are related to any member or senior officer of the Council.

J. NEVILLE KNOX,
Town Clerk.

Municipal Offices,
Harrogate,
19th January, 1953. E7065

TRENT RIVER BOARD

APPOINTMENT OF TWO ENGINEERING ASSISTANTS

Applications are invited for the appointment of two ENGINEERING ASSISTANTS at the Board's Head Office, Nottingham.

The salaries will be within A.P.T. Grades I to V(a) (£465–£685 per annum) of the National Scheme of Conditions of Service, according to experience and qualifications.

Preference will be given to candidates holding professional qualifications or possessing a University Degree, and who have had experience in carrying out river improvement works.

Applications, with full particulars, including copies of testimonials or the names of referees, must reach the Engineer to the Board, Trent River Board, 206, Derby Road, Nottingham, within fourteen days of the date of the publication of this advertisement.

JOHN HIRST,
Clerk of the Board.

E6978

PUBLIC APPOINTMENTS

CITY OF LEEDS

WATERWORKS DEPARTMENT

APPOINTMENT OF TECHNICAL STAFF

Applications are invited for the undermentioned appointments :

(a) CHEMIST and BACTERIOLOGIST, A.P.T. Grade IX, £815–£935.

(b) ENGINEERING ASSISTANT, A.P.T. Grade VIII, £760–£835.

(c) ENGINEERING ASSISTANT, A.P.T. Grade VIII, £760–£835.

Applicants for post (a) must have had experience in the bacteriological, as well as the chemical, examination of water.

Applicants for post (b) must have had experience in the design and construction of reinforced concrete water retaining structures and experience in design and installation of rapid gravity filtration works and pumping plants will be an advantage.

Applicants for post (c) must have had experience in the design and construction of large dams.

Applicants for post (a) must have a University Degree and/or other professional qualifications.

Applicants for posts (b) and (c) must be Corporate Members of the Institution of Civil Engineers.

The grading of the posts and conditions of service are in accordance with the A.P.T. Division of the National Scheme of Conditions of Service.

The appointments are subject to the provisions of the Local Government Superannuation Act, 1937.

Selected candidates will be required to pass the Corporation's medical examination.

The persons appointed will be required to devote the whole of their time to the business of the Corporation, and will not be allowed to engage, either directly or indirectly, in private work of any kind.

The appointment will be subject to one month's notice on either side.

Applications, on forms to be obtained from the undersigned, should be delivered not later than 12 noon on Thursday, the 5th February, 1953, endorsed with the description of the post applied for.

Canvassing in any form, either directly or indirectly, will be a disqualification.

KENNETH L. FORSTER,
General Manager and Engineer.

Waterworks Department,
Civic Hall,
Leeds, 1,
12th January, 1953. E6979

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

ENGINEERS AND PHYSICISTS

ENGINEERS and PHYSICISTS (particularly with electronics) required for appointments in (a) Senior Scientific Officer and Scientific Officer grades (Ref. A246/52A), and (b) Senior Experimental Officer, Experimental Officer and Assistant Experimental Officer grades (Ref. A247/52A), in Experimental Establishments in London, Portsmouth, Weymouth areas and Scotland. Candidates, British subjects, for (a) must possess First or Second-Class Honours Degree in Physics or Engineering, or high professional attainments such as Corporate Membership of appropriate professional institution with suitable experience and responsibility, and for (b) should possess one of following qualifications :—University Degree in Science, Engineering or Mathematics, Graduate Membership of appropriate professional institution, Higher National Certificate, Final Certificate of five-year grouped course in relevant subject at City and Guilds of London Institute or comparable institution, Higher School Certificate with Mathematics or Science as principal subject or equivalent qualification. S.S.O.s at least 26 years of age with at least three years' approved experience, London salary scale (men), £812–£1022 per annum ; S.O.s at least 21 years, £440–£707 ; S.E.O.s at least 35 years, £844–£1075 ; E.O.s at least 26 years, £628–£786 ; A.E.O.s at least 17½ years, £274–£586. Rates for women and posts in Provinces somewhat lower. Starting salaries above minima may be granted according to age and experience. All appointments unestablished (with F.S.S.U. for S.S.O. and S.O.), but with some opportunities to compete for established posts—Application forms from M. of L. and N.S., Technical and Scientific Register (K), Almack House, 26, King Street, London, S.W.1, quoting appropriate reference. E7029

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS DEPARTMENT, GAMBIA

EXECUTIVE ENGINEER

Applications are invited for the following post :—EXECUTIVE ENGINEER (CSD 64/12/01).

Duties would include survey, design, construction and maintenance of civil engineering works, including buildings, roads, water supply, &c. Appointment is permanent and pensionable, subject to satisfactory completion of three-year probationary period. Salary in incremental scale £570–£1000 per annum ; point of entry determined by age, experience, and war service. Pensionable expatriation pay varying from £150–£300 p.a., according to basic salary and temporary variable non-pensionable cost-of-living allowance of £110 p.a., also payable.

Furnished quarters at moderate rents, free first-class passages for officer and wife on first appointment and leave.

Candidates must hold a University Degree or Diploma in Civil Engineering, carrying exemption from Parts A and B of the A.M.I.C.E. examinations, and have had two years' practical experience, or be Associate Members of the Institution of Civil Engineers.

Full details available on application.

Intending candidates should apply in writing to the Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, S.W.1, giving brief details of their age, qualifications and experience. They should mention this paper and quote the reference number CSD/64/12/01. E7055

PUBLIC APPOINTMENTS

HER MAJESTY'S COLONIAL SERVICE

EAST AFRICAN RAILWAYS & HARBOURS ADMINISTRATION

ASSISTANT MECHANICAL ENGINEERS

Applications are invited for the following posts :—ASSISTANT MECHANICAL ENGINEERS (CDE 110/88/04), East African Railways and Harbours Administration.

General duties of an Assistant in the running and workshops sections of the Mechanical Department of a Railway. Appointment is pensionable on probation in salary scale £590 to £1040, point of entry depending on age. Temporary allowance of 30 per cent at present payable. Free passages on appointment and on leave for officer, his wife and children up to the cost of one adult passage. Leave at rate of 4½ days for each month of residential service.

Candidates between the ages of 25 and 30 must have passed or be exempted from Sections A and B of the Associate Membership Examination of the Institution of Mechanical Engineers and have served an apprenticeship with a British-owned railway or a firm of locomotive builders, followed by a minimum period of four years' experience in locomotive operation and maintenance, and they should have held a post of responsibility in the mechanical department of a railway of recognised standing.

Intending candidates should apply in writing to the Director of Recuitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, S.W.1, giving brief details of their age, qualifications and experience. They should mention this paper and quote the reference number CDE 110/88/04. E7002

NATIONAL COAL BOARD

ENGINEERING BRANCH OF PRODUCTION DEPARTMENT

MECHANICAL AND ELECTRICAL ENGINEERS

National Coal Board invite applications for the undermentioned superannuable appointments under the Power Generation Engineer in the Engineering Branch of Production Department at London Headquarters :—

ASSISTANT ENGINEER (Mechanical). Salary range £650 to £1250 per annum, according to qualifications and experience. Applicants should have experience in the design and construction or operation of steam power plants and preferably some knowledge of gas turbines and the combustion of low-grade fuel. (Reference TT/581.)

ASSISTANT ENGINEER (Electrical). Salary as quoted above. Applicants should have experience in the electrical aspects of design and construction or operation of steam power plants and some knowledge of transmission and distribution of electric power. (Reference TT/582.)

Experience in the preparation of specifications and negotiation of contracts is desirable in both instances.

Apply in writing, giving full particulars (in chronological order) of age, education, qualifications and experience (with dates), to National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, marking envelope with relevant TT reference number quoted above. Closing date 7th February, 1953. Original testimonials should not be forwarded. E7010

BRITISH ELECTRICITY AUTHORITY

LONDON DIVISION

APPRENTICES' INSTRUCTOR

Applications are invited for this position at the Apprentices' Training School, which is being equipped at the Bankside Generating Station, S.E.1. Candidates should have had sound practical and technical mechanical engineering training and experience or workshop practice in mechanical engineering. They must be able to demonstrate their ability to impart instruction and teaching experience is therefore desirable. Candidates must be able to prepare a syllabus for the course of instruction, plan the work, lecture and give practical instruction. They will be required to carry out instruction in all the basic mechanical engineering skills and to enable apprentices to acquire the elements of the blacksmiths' and welders' techniques and proficiency in the operation of machine tools. Salary and conditions of service in accordance with N.J.B. Schedule C, Class AX/EX, Grade 5 (3rd Assistant Engineer), with an ultimate salary of £927 3s., including London allowance. Commencing salary in accordance with qualifications, but will be not less than £740 5s., including London allowance.

Applications must be made on the form obtainable from Divisional Secretary, B.E.A., London Division, Generation House, Great Portland Street, W.1, and be returned within fourteen days of this advertisement. E6999

MIDDLESEX COUNTY COUNCIL

MAIN DRAINAGE DEPARTMENT

ENGINEERING ASSISTANT

ENGINEERING ASSISTANT required at West Middlesex Drainage Works, Isleworth. Salary, A.P.T. I, £485 by £15 to £530 p.a. (plus £10 if 26 or over). Established, subject to medical assessment and prescribed conditions. Preference given if holding University Degree in Engineering and/or Parts A and B of Examination of Institution of Civil Engineers.—Applications, with names of two referees, to Chief Engineer, Main Drainage Dept., Middlesex County Council, Isleworth, Middx, by 14th February (quoting L.620 E). Canvassing disqualifies. E7062

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF SOUTHEND-ON-SEA

PIER AND FORESHORE DEPARTMENT

ASSISTANT ELECTRICAL & MECHANICAL ENGINEER

Applications are invited for this appointment.

Age limit 40 years (45 if already in local government superannuation scheme).

Salary, A.P.T., Grade II, of the National Scale (£495 by £15 to £540 p.a.). The appointment is terminable by one month's notice on either side.

Applicants should have served either an electrical or mechanical engineering apprenticeship, hold good technical qualifications, and have had general experience subsequently to apprenticeship, and be capable of undertaking the supervision (under the Chief Electrical and Mechanical Engineer) of the installation and maintenance of plant of the department which includes traction system, maintenance of both rolling stock and permanent way, electrode boilers, water filtration plant, cranes, pumps, diesel electric dredger, large electrical installation, and water and gas services of the department.

Medical examination, superannuation deductions provided.

Application, stating age, full particulars of training and experience, accompanied by three testimonials, must reach the Piermaster and Foreshore Manager, Pier Hill Buildings, Southend-on-Sea, in a plain envelope, endorsed "Assistant Engineer," not later than 9 a.m. on Monday, 16th February, 1953.

ARCHIBALD GLEN,
Town Clerk.

E7000

WEST KENT MAIN SEWERAGE BOARD

ENGINEERING ASSISTANTS

Vacancies exist for :—

(a) SENIOR ENGINEERING ASSISTANT, Grade VIII (£760–£25 by 3–£835 plus London "weighting"). Applicants must be Chartered Civil Engineers with experience of sewage purification works and sewerage systems.

(b) ENGINEERING ASSISTANT, Grade V (£595–£15 by 2–£20–£645 plus London "weighting"). Applicants should be Chartered Civil Engineers or have other appropriate professional qualifications, supported by experience of hydraulic or structural engineering.

Applications for these appointments, on forms obtainable from me, should be submitted by Monday, 26th January, 1953.

A. J. W. JEFFERY,
Secretary.

"Barnfield," 20, Blyth Road,
Bromley, Kent. E6917

COLNE VALLEY SEWERAGE BOARD

SEWAGE DISPOSAL PLANT

SHIFT ENGINEER

SHIFT ENGINEER required for permanent pensionable position on large modern sewage disposal plant. Duties include supervision of the power-house containing six gas/diesel-driven 750kVA alternators and associated switchgear, centrifugal air compressors, pulverised fuel furnaces, vacuum filters, digested sludge extraction plant, pumping stations, &c. &c. Salary £525, rising to £570 per annum. House accommodation at economic rent will be provided.

Applications, stating age, qualifications and experience, to Chief Engineer, Colne Valley Sewerage Board, Maple Lodge, Maple Cross, Rickmansworth, within ten days of appearance of this advertisement. E7067

THE PARSONS AND MARINE ENGINEERING TURBINE RESEARCH AND DEVELOPMENT ASSOCIATION

RESEARCH ENGINEERS

The Parsons and Marine Engineering Turbine Research and Development Association has vacancies for RESEARCH ENGINEERS :

(1) For aerodynamics and heat transfer work.

(2) For research and development on steam and gas turbine components.

The work is interesting and purposeful, and good salaries are paid varying with age, qualification and experience. Candidates, who should be Honours Degree men, are requested to apply in writing to the Research Director, Pametrada Research Station, Wallsend. E7048

PADDINGTON COUNCIL

HALLFIELD HOUSING SITE

TEMPORARY ASSISTANT RESIDENT ENGINEER

Paddington Council require TEMPORARY ASSISTANT RESIDENT ENGINEER to assist in the supervision of the construction of multi-storey flats in reinforced concrete on the Hallfield Housing Site. Salary within scale £495 by £15 to £540 (£15 less if under age 26), according to qualifications and experience. Previous experience in reinforced concrete work is essential, and preference will be given to candidates who have suitable technical qualifications. N.J.C. service conditions ; one month's notice ; superannuation.—Applications, stating age, qualifications, present and previous appointments, experience, and the names and addresses of three referees, to the Town Clerk (A.106), Paddington, W.2, by 2nd February, 1953. E7020

THE ENGINEER

JANUARY 23, 1953

Lloyd's Register of Shipping

THE 1953 edition of the Appendix to Lloyd's Register Book was issued this week. There are notes on the 1952 statistical tables, including a list giving the gross tonnage of the principal merchant fleets of the world, together with figures indicating an increase or decrease in the individual totals compared with 1951. The world total, which stands at 90,180,000 tons, is 2,935,000 tons more than the previous year and the following countries have returned the largest increases :—Japan, 605,000 tons ; Italy, 372,000 tons ; Germany, 367,000 tons ; Liberia, 303,000 tons ; France, 271,000 tons ; and Sweden, 219,000 tons, while the overall increase for the British Commonwealth was 163,000 tons. A comparison with 1939 shows that the largest increases were made by the United States of America, 15,883,000 tons ; Panama, 3,023,000 tons ; and Norway, 1,072,000 tons ; while decreases are still recorded for Germany, 3,085,000 tons ; and Japan, 2,843,000 tons. Consideration of size and age continues to reflect wartime building, by the preponderance of ships of 6000 tons to 8000 tons, although a large number of these ships are not in service. The largest amount of post-war tonnage falls within the size 10,000 tons to 15,000 tons, mainly due to oil tanker construction. Since 1951 the world total of oil tankers has increased by 1,460,000 tons to 19,989,000 tons, representing 22 per cent of the grand total. Of the world tonnage, motorships represent 29 per cent, a 2 per cent increase over the previous year ; however, there are wide variations between countries, the percentage of motorships in Norway, Sweden and Denmark being 77, 73 and 72 respectively. There is much more general employment of oil, which is now used as fuel in 85 per cent of the total steam and motor tonnage, while only 15 per cent uses coal, compared with 45 per cent in 1939 and 97 per cent in 1914. At the end of June, 1952, 9885 ships of 37,682,000 tons gross, representing nearly half the world total, were entered in the Register Book to the Society's classification.

The Production of Gas and Carbonised Fuels

THE Institute of Fuel and the Southern Section of the Coke Oven Managers' Association recently held a joint meeting in London, at which a paper on "The Production of Gas and Carbonised Fuels" was presented by Mr. H. D. Greenwood, of the National Coal Board. In surveying the carbonising industries, Mr. Greenwood said that they used about 25 per cent of the coal produced in this country. The coking industry, which in the main consisted of the plants operated by the National Coal Board and the iron and steel industry respectively, carbonised coal primarily to make metallurgical coke, though the Coal Board's coke oven plants also supplied some 60 per cent of the coke used by other industries. The gas industry, which supplied most of the coke used by domestic consumers, produced twice as much gas as the coking industry, although carbonising only about 15 per cent more coal. A considerable proportion of the gas used by the coking industry, Mr. Greenwood explained, was used for internal purposes, and the quantity supplied to area gas boards represented about 13 per cent of the gas made by the gas industry. Mr. Greenwood went on to say that the output of gas by the gas industry might increase at the rate of about 3 per cent a year, and it seemed probable that that would necessitate the carbonisation of an additional 8,000,000 tons of coal annually by 1960. To meet the increased requirements of coke for the steel industry and other purposes the coal consumption of the coking industry might increase by about 3,000,000 tons annually over the same period, and as there might not be sufficient high-grade coking and gas coal available, blending a proportion of lower-grade coal would become necessary. Mr. Greenwood thought that the availability of different grades of carbonisation coals and the new coal price structure might materially affect the future economics of both the gas and coking industries. It might, therefore, prove economic for the gas industry to develop methods of complete gasification which could use coals unsuitable for carbonisation.

Iron and Steel Bill Amendments

THE Minister of Supply, Mr. Duncan Sandys, has tabled some Government amendments to the Iron and Steel Bill, which implement the assurances given to ironfounders during recent discussions about the proposals made in the Bill to bring their activities within the supervision of the proposed Iron and Steel Board. One amendment provides for the exemption of foundries from the duty of submitting development schemes for the approval of the Board. Others limit the Board's powers over obtaining information ; clarify the Board's powers regarding prices, and empower the Minister of Supply to fix a limit which the Board shall not exceed in raising from the industry contributions towards its expenditure. There is another amendment which clarifies the definitions of "rolling" and "forging" in the Third Schedule of the Bill. This makes it clear that there is no intention that the proposed Board's supervisory powers should include processes that belong essentially to the engineering industry. Clause 13 of the Bill sets out the proposed Board's powers for obtaining information. The amendment revises this clause so that information may be sought only on production, which includes stocks, capacity and raw materials ; on costs, though only in respect of products coming within the Board's price-fixing powers, and on imports of raw materials. This indicates, of course, that no demand can be made from foundries about costs, except where maximum prices have been laid down because of monopoly conditions or restrictive practices. About the contributions which firms may be called upon to make towards the Board's expenditure, the amendment provides that these shall be assessed on the basis of the firms' iron and steel activities only.

Productivity Report on the Heavy Chemicals Industry

THE British Productivity Council has published the report of a team representative of the heavy chemicals industry, which visited the U.S.A. in March and April last year. The team, which was led by Mr. J. Grange Moore of Imperial Chemical Industries, Ltd., consisted of seventeen members selected from the supervisory, technical and workshop levels of the industry. From the information which it collected during its tour, the team expresses in its report the unanimous opinion that the productivity of many American heavy chemical factories, if measured by the added value per employee, or by sales value per employee, is at present at least three times that of the British on the basis of the present rate of exchange. But, it is added, if measured by the work units performed in a week by the hourly paid workers, the productivity of the American industry is estimated to be slightly lower than the British. Comparing the heavy chemical industries of the two countries, the team found that the American companies had, on average, one technically qualified man to every six hourly-paid workers, whereas in the British industry the ratio is about one to every sixteen. Although, as the report remarks, this is a tribute to the quality of the British technicians, the team recommends that the number of technical graduates in this country's heavy chemical industry should be increased as quickly as possible as the primary requirement for attaining greater productivity. Other recommendations made by the team concern the better use of capital and equipment ; the continuous training of all employees, particularly in the significance and use of costs ; the more effective utilisation of foremen and junior supervisors, and the greatest use of work study to improve, for example, the efficiency of maintenance and the handling of materials. The trade unions are urged to modify apprenticeship schemes to ensure a more intelligent use of craft ability. Finally, the team suggests that the Association of British Chemical Manufacturers should develop the free interchange of technical information, of statistics and of work-study techniques within the chemical industry, and should re-examine the problems of obtaining plant, equipment and instruments, and of specialised training in instrumentation and automatic control.

Safety in Mines Research Report

THE thirtieth annual report on Safety in Mines Research, which has just been published, gives a general review of progress during 1951. In the section of the report dealing with fire and explosion hazards, it is stated that the fire research team which was set up in 1950 spent much of the year investigating the problems arising directly from the fire at Creswell Colliery, and a number of the experiments are described in some detail. During the year under review there were three serious explosions—at Easington, Eppleton and Weetslade collieries, in the Northumberland and Durham collieries. It is considered that for some of the conditions created by modern methods of mining the stone-dust remedy, as customarily applied, is inadequate—particularly where extensive belt conveyor systems are involved. In this connection, the report states, a very careful study has been made of stone-dust barriers and new forms of barriers are being studied at Buxton. Dealing with work on engineering and metallurgical research, the report points out that, owing to the transfers which had to be made of the mines supports section, the winding and wire ropes section, and the metallurgical section, the work of these sections suffered. Progress was made during the year in the development of yielding supports and in the application of non-destructive testing techniques to mining equipment. In connection with dust control and the pneumoconiosis hazard the Safety in Mines Research Establishment is preparing dusts of known composition and size distribution for experiments on animals by the Medical Research Council, and is continuing to co-operate in studying the dust found in the lungs of coal miners. Research has been directed on improving the methods of assessing the quantity and the composition of air-borne dust, and on the prevention of dust produced by drilling machines. The report concludes with a useful synopsis of research reports and published papers in 1951.

Cavitation

By E. CREWDSON*

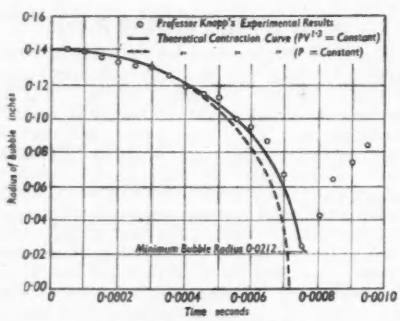
The author suggests that the damage done by cavitation is not the consequence of the collapse of bubbles. He maintains that such collapse cannot take place. But the high pressure and the high temperature of the gas within the bubble can account for observed damage under cavitating conditions.

MUCH is known about the occurrence of cavitation in water turbines, ship's propellers, pumps and other hydraulic equipment. The beautiful observations made by Professor R. T. Knapp and reported in his James Clayton Lecture last April have substantially increased that knowledge and have made it possible to state with certainty that some of the suggestions of the past as to the causes of cavitation damage are no longer tenable.

Professor Knapp photographed a spherical bubble having a maximum radius of 0·14in by means of a cinematograph camera taking exposures at the rate of 20,000 frames per second, and was thus able to obtain a picture of the radius-time history of the compression and subsequent expansion of the bubble.

The writer is unable to agree with Professor Knapp that the bubble of which he gave a life history ever collapsed. Certainly no frame of the cinema film reproduced in his lecture shows the complete disappearance or collapse of the bubble. Indeed, the fact that the bubble re-expanded after a negligible time interval and followed the same kind of radius-time history in expansion as it did in compression makes it quite certain that it never collapsed.

If a bubble did collapse or completely disappear in the surrounding liquid it could not begin to reform without a finite time interval—an interval which would be of the order of the time taken for the bubble to collapse from its maximum size.



Initial pressure in bubble 3·2 p.s.i.
External pressure in fluid 3·0 p.s.i.

Note. The time when the bubble obtained its maximum dimensions has been taken 0·00005 seconds earlier than in Fig. 15 of Professor Knapp's lecture.

Fig. 1—History of Contraction of Cavitation Bubble

Lord Rayleigh, in his Scientific Paper No. 423 (1917) has examined the behaviour of a spherical bubble of a perfect gas introduced into an infinite field of water and has shown that if the pressure in the field of water is superior to that of the gas in the bubble, the bubble will be compressed to a minimum finite size and will then re-expand. Lord Rayleigh assumed that such compression would take place isothermally and showed that if there were no losses the bubble would re-expand to its original size and thereafter would continue to contract and expand between two limits, one of which would be the bubble's initial size.

Professor Knapp has shown that the compression history of the bubble as predicted by Lord Rayleigh is similar to the history of the bubble's contraction as actually photographed.

It is possible to develop Lord Rayleigh's equations on the assumption that the bubble of gas is compressed adiabatically and it is then found that the correspondence between the theoretical adiabatic compression curve and the experimental one is much closer than it was when the compression was assumed to be isothermal. (See Fig. 1.)

If it is accepted that a cavitation bubble filled with water vapour is compressed adiabatically in a field of water where the pressure initially is higher than that of the vapour, it follows that at its maximum compression the bubble contains highly superheated steam at a substantial pressure.

Supposing such a bubble were thus compressed in contact with a metal surface, it is probable that the superheated steam would attack the metal surface and, in any case, the substantial momentary differences of temperature at neighbouring points of the metal surface could generate electric currents in the metal leading to electrolytic effects, especially in sea water.

Cavitation attack may result in damage to metal surfaces of very varying character. It may produce a spongy surface as though the metal had been chemically attacked, or it may cause depressions as though the metal had been repeatedly struck with a ball-ended hammer. The spongy type of attack is characteristic of cavitation in water turbine runners near their discharge surfaces. The hammer-blow attack is common on the bosses of ships' propellers.

Both these effects are explained if Lord Rayleigh's calculations—modified for adiabatic compression—are accepted as correct.

To secure general acceptance it is certain that the foregoing statements and arguments must be amplified.

The first step in such amplification is to demonstrate that an empty bubble collapsing in a field of water could not possibly begin to reform instantaneously, accepting that water has its known compressibility. Whilst a rigid mathematical proof of this is doubtless possible, it is more clearly demonstrated, by a simple analogy, to those—like the writer—who have forgotten most of their mathematics. In Fig. 2 the circular space *A* represents an empty sports ground where athletic contests are about to begin. The space *A* is surrounded by a very large crowd of spectators, whose unusual characteristic is that they can all run at exactly the same rate as one another under the same physical and psychological influences. In the centre of the field *A* is a loud-speaker *B* connected by leads to a microphone *C* clear of the spectators. An eccentric millionaire now takes his place at the microphone and announces that he will give a prize of 100,000 dollars to the first spectator who reaches the centre of the field *A*. As soon as the sound of the message reaches the inner ring of spectators they begin to run towards the loudspeaker, and as the sound travels further, more and more of the spectators begin to do the same until the whole crowd is moving towards the centre of the field *A*. Clearly as the leading spectators get nearer they will increase their efforts to arrive first and will run faster and faster. Finally, they will meet at the centre. (The bubble has collapsed.) The pressure at the centre will now become intolerable and the sound of the agonised screams of those at the centre will begin to reach those further and further from the centre, but until it has done so they will still be running forward towards the centre, adding to the state of congestion there. Until the outer fringes of the crowd hear the screams at the centre they will not begin to reverse their motion and the pressure at the centre cannot be relieved. (The bubble cannot reform.)

It is clear from this analogy that a finite time interval (depending on the velocity of sound in water) must elapse before an empty bubble which has collapsed can begin to reform.

Professor Knapp's photographs show that a bubble, which was contracting in one frame and there measured about 0·03in radius, had expanded in the next frame to about 0·04in radius. According to him the bubble had in the meantime collapsed, and all this had happened in 0·00005 seconds. From what has been said above, this is impossible. The explanation is that the bubble did not collapse but was highly compressed to a minimum finite radius.

Now if the bubble contents were water vapour and were compressed isothermally it is certain that the water vapour would condense during the compression and the bubble would in fact collapse almost as though it were empty. This we have shown it did not do.

The loss of energy of the bubble was so small that on re-expansion it attained a radius of 0·12in. Had there been no loss at all it would have attained a radius of 0·14in. The only efficient modes of compressing gas are either isothermal or adiabatic. Any intermediate mode is inefficient. (See *Theory of Sound*, by Lord Rayleigh, second edition, Vol. II, page 26.) We are thus justified in saying that the compression of the vapour in Professor Knapp's bubble must have been nearly adiabatic.

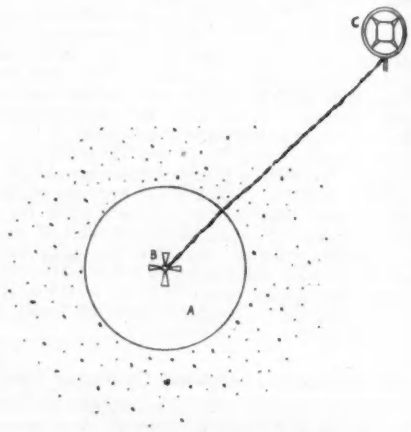


Fig. 2—Analogy of the Eccentric Millionaire

And, indeed, a reasonable assumption of heat transfer from the water vapour in the bubble to the surrounding field of water leads to a similar result. If we assume that the surrounding water is a perfect conductor of heat and that the vapour in the bubble is also a perfect conductor, but that between the two there is interposed an infinitesimally thin shell which has a resistance to the passage of heat, we can make some calculations. Suppose the thin shell had a thermal resistance equivalent to that of the known resistance of a layer of water

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vapour having a thickness equal to one-third of the bubble radius. Professor Knapp's bubble would have lost about 60 deg. Fah. in being compressed from 0·14in radius to 0·04in radius and its temperature instead of being 1100 deg. Fah. would be about 1040 deg. Fah. at that radius. It was compressed in fact substantially further and therefore must have reached a maximum temperature much hotter than this.

Professor Knapp's bubble was formed in water (at 74 deg. Fah.) having a vapour pressure of about 0·4 lb per square inch absolute. Because of the speed at which this bubble was formed it is reasonable to assume that the actual vapour pressure in the bubble at its maximum radius was substantially less than this. Suppose it was 0·2 lb per square inch absolute. The pressure in the field of water surrounding the bubble was about 3 lb per square inch absolute. Lord Rayleigh's calculations (modified for adiabatic compression with $\gamma=1\cdot3$) show that the bubble would be compressed to a minimum size of 0·0212in radius. Assuming no loss of heat at all from the bubble a reference to Keenan and Kaye's Gas Tables will show that the pressure of the vapour in the bubble must have been about 283 lb per square inch absolute and its temperature 2043 deg. Fah. Here then we have the highly superheated steam available for doing damage to metal with which it comes in contact.

Now let us consider the case of a ship's propeller boss. Here the conditions are different. Suppose, for instance, that the boss is 10ft below the water surface. The pressure in the field of water surrounding the boss will be about 19 lb per square inch absolute. It is probable that cavitation bubbles will not be of pure water vapour but more likely will have contents approximating to air. Suppose, then, that such a bubble is formed in the wake of the stern tube and is carried aft by the wake to compression on the propeller boss. Again suppose that its pressure at its maximum size is 0·5 lb per square inch absolute. Assuming that the air in compression follows the law $PV^{1.4}$=Const., the final volume of the bubble will be $^1/_{1000}$ of its maximum volume. From Keenan and Kaye's tables and assuming no loss of heat the pressure of air in the bubble would be about 5180 lb per square inch absolute and its temperature 4950 deg. Fah.

If this high pressure bubble came in contact with the propeller boss, the surface layers of the metal would be heated and the metal would be consequently weakened so that the high air pressure could cause flow of the metal to take place. Any such flow of the surface would cause further heat due to the work done, and it is easy to see that the relatively modest air pressure could do the damage which is in fact observed. It is almost certain that there are wide fluctuations of pressure in the disturbed field of water round the propeller, and that much higher pressures than the assumed figure of 19 lb per square inch absolute might at times be available for compressing the bubble.

That the "peened" type of damage takes place more usually on the boss of a propeller is due to the fact that air bubbles are likely to travel to the centre of the vortex caused by the propeller's rotation.

It seems unlikely to the writer that this kind of damage would take place on propellers of submarines because such propellers would more often be so far submerged that air bubbles could not form.

Let us now sum up the conclusions we have reached.

The two main kinds of cavitation damage can be fully explained as the result of attack by highly compressed bubbles of vapour or gas. The major part of the energy available for the attack is stored in the bubbles and not in the surrounding water. The high temperatures attained in the bubbles assist the attack and in some cases may be the primary cause of damage. The resulting temperature gradients in the metal attacked may produce thermo-electric effects, which will lead to electrolytic attack particularly in sea water.

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APPENDIX

The formulæ used to calculate the times of compression of bubbles were as follows :—

(i) $$U^2=\frac{2P}{3\rho}\left(\frac{R_o^3}{R^3}-1\right)$$

This is Lord Rayleigh's equation (4) and applies to an empty bubble.

(ii) $$\tau=0\cdot9147\ R_o\sqrt{\frac{\rho}{P}}$$

This is Lord Rayleigh's equation (6) and gives the time of complete collapse of an empty bubble.

(iii) $$U^2=\frac{2P}{3\rho}\left(\frac{R_o^3}{R^3}-1\right)-\frac{2Q}{3\rho}\frac{R_o^3}{R^3}\left[\frac{\left(\frac{R_o}{R}\right)^{3\gamma-3}-1}{\gamma-1}\right]$$

This is Lord Rayleigh's equation (7) modified by Dr. B. Heys to allow for adiabatic instead of isothermal compression of a gas bubble.

(iv) The meanings of the symbols are :—

U=Velocity of the boundary of the bubble.
R_o=Initial value of the radius of the bubble.
R=Radius of the bubble at time t.
P=Pressure in the field of water compressing the bubble.
Q=Initial pressure of gas or vapour in the bubble.
ρ=Density of water.
γ=Ratio of specific heats, taken as 1·4 for air, and 1·3 for water vapour.

The pressures and temperatures of the gas and the vapour bubbles were calculated, using "Gas Tables" by Keenan and Kaye, New York, 1948. (Table 16 was used for water vapour and Table 1 for air).

For a given ratio $\frac{P}{Q}$, the ratio of compression of a bubble $\left(\frac{R}{R_o}\right)^3$ was calculated by Lord Rayleigh for isothermal compression of a perfect gas contained in the bubble surrounded by water. The following table gives Lord Rayleigh's figures and compares them with the ratios which would be obtained if gases were compressed adiabatically, which followed the relations $PV^{1.4}$=constant, and $PV^{1.3}$=constant.

$\left(\frac{R}{R_1}\right)^3$ Ratio of Volumes	$\frac{P}{Q}$ Ratio of Pressures		
	Isothermal (Rayleigh)	Adiabatic $\gamma=1\cdot4$	Adiabatic $\gamma=1\cdot3$
1/1000	6·91	37·4	23·1
1/300	5·65	22·1	15·2
1/100	4·65	13·4	10·0
1/10	2·56	4·2	3·68
1/4	1·85	2·47	2·39
1/2	1·38	1·60	1·54

Oil from Coal in South Africa

(By Our African Correspondent)

INTENSIVE activity prevails at present at the works of the South African Coal, Oil and Gas Corporation, known as Sasol, near Coalbrook, both in the creation of the township dependent on this project and the erection of the plant for the extraction of oil from coal. Sasol is a public company, the shares of which are held by the Government through the Industrial Development Corporation. The project includes the mining of coal from Sasol's own colliery, one and a half miles from Coalbrook Station, 55 miles south of Johannesburg in the Orange Free State. The plant involves the erection of two parallel synthesis plants for the treatment of the coal, which is brought from the pithead by conveyor belt to the factory one and a half miles away because of the need for firm foundations.

Foundation work for the plant is progressing. The rail link from Coalbrook Station to the new plant is complete, the distance of the factory by rail from Coalbrook being about 3 miles. In addition to this line and its accompanying marshalling yards there is a comprehensive layout totalling nearly one and a half miles within the factory area.

As is well-known, two basic processes have been evolved for the production of oil from coal. The one is the liquefaction by direct hydrogenation of finely ground coal—a process which is applicable to selected South African high-grade coals. The second process is applicable to low-grade coals, of which South Africa has almost unlimited reserves, and is the well-known Fischer-Tropsch process. Before the second world war the Americans and Germans were collaborating in the perfection of this process but, with the break created by the war, scientists from the two countries evolved separate versions. Sasol is combining the two—the German and the American—to suit South African conditions.

Because of the large quantity of steam required for the Fischer-Tropsch process, Sasol will have its own power station, using the fine coal from the Sasol colliery. There is also an oxygen plant, with six Linde oxygen manufacturing units, processing 7500 tons of air a day, and producing 1500 tons of oxygen for the gasification plant, which will consume about 3200 tons of coal a day. The gasification plant will consist of nine Lurgi pressure gasification units. The gas stream, after purification, will be taken through the Kellog circulation catalyst units and the Ruhrchemie-Lurgi fixed-bed catalyst synthesis plant. After condensation the primary products go into the working-up section.

Sasol's objective is to produce petrol and diesel oil at a low price, and this side of its production will account for three-quarters of the revenue. With the present rate of increase in the use of petrol in South Africa, however, it is not expected that Sasol will do more than cope with the increase in the country's need, year by year. By 1955 it is hoped that Sasol will be producing one-eighth of the country's requirements in both petrol and diesel oil.

The ammonia liquor from the gasification plant will be produced at the rate of 25 tons a day. In terms of nitrogen this represents two-thirds of the Union's imports of nitrogen fertilizer and about half of the imports of 1951. The gasification plant will also produce 3,000,000 imperial gallons of low-temperature tar a year, from which a certain amount of tar acids will be extracted, according to the demand for them. The by-products from the process of petrol synthesis include a range of oxygenated organic solvent-materials. Among the main by-products will be some 14,000 tons of paraffin wax, half of which will be micro-crystalline An important contribution which Sasol will make to South African industry is the provision of fuel gas to the metal-working industries, to replace expensive coke or imported fuel oil. To meet production it is estimated that the Sasol colliery will mine 7000 tons of coal a day.

Because of the highly mechanised mines and factory plant the native labour force, it is estimated, will not exceed 1000. About 350 artisans, many of them from Germany, are being brought into the country as Sasol employees.

A Critical Review of Gas Turbine Progress, 1952

(Contributed)

Now that British-made gas turbines are in service in power stations, locomotives and ships, performance for those three purposes is reviewed. The conclusions are drawn that oil-burning gas turbine locomotives as at present built are unlikely to compete successfully with steam locomotives in this country, nor are oil-fired gas turbine power station plants here likely to compete with coal-fired steam turbine plants for normal duties ; but at sea the gas turbine shows promise of further successful development. The conclusions do not necessarily apply in other parts of the world where the relative costs of oil and coal may differ from those in this country.

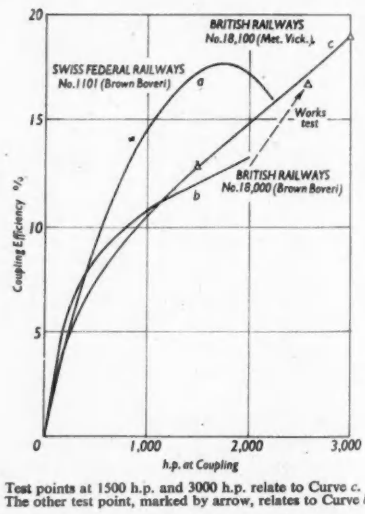
SEVEN years after the war we can at last record that British-made gas turbines are in service in power stations, in locomotives and in merchant ships. It is therefore appropriate to reflect on the position in the light of the results, so far as they are available, in relation to the next stage in development. It can be said immediately that these trial plants have turned out much as expected, except for the delays in manufacture. They are not free from trouble, but the troubles are not fundamental or irremediable. On the other hand, and this may seem paradoxical, it is also fairly clear that except in the marine application they will not be repeated. This is not to say that the gas turbine locomotive or the power station gas turbine is a failure. Both the locomotive sets have in fact fulfilled their guarantees on test. The power station gas turbine has not yet been tested. The position is simply that because we are a country producing coal, but importing oil, oil costs several times the price of coal ; hence oil-burning plant, in order to compete on a commercial basis, must show either an efficiency roughly 1·5 to three times that of orthodox coal-burning plant (according to the quality of the coal) which it seeks to supplant, or some approach to this together with important additional advantages. This the gas turbine is as yet unable to do, either in the locomotive or in power stations. In this respect the position has remained practically unchanged since 1946, when the conclusion could already be arrived at that, contrary to popular opinion, the gas turbine as it existed (and still exists) in the oil-burning form would be unable to claim any commanding competitive position in this country. The future prospect, when and if much higher temperatures can be employed successfully, is, of course, more attractive, as the gain with each increment of temperature both on efficiency and specific output is more marked with air than with steam. The situation may also be appreciably altered for some applications by the development of a successful, simple, commercial coal-burning turbine, which has not yet been achieved. The advantages of the gas turbine accordingly are still mainly future hopes, while in the present locomotive application, even burning heavy oil, its position is still no better than marginal. For power station use the only ordinary commercial prospect when burning oil in a coal country is for pure peak load duty, for which fuel cost is of minor account, but the capital cost must be low. In the public electricity supply field it is particularly difficult to compete on capital cost because of the existence of time-expired steam plant which stands at zero book value, though quite usable for peak load. If, therefore, we rule out the possibility of discovering some unforeseen advantage in operation as being hardly likely, since the merits of the gas turbine have already, it appears, been somewhat overstated (while the difficulties have proved more severe than anticipated), then operating experience can hardly be expected to do more than show up unforeseen weaknesses, thus worsening the general commercial position compared with the paper assessment.

Locomotives

The " Metrovick " 3000 h.p. locomotive No. 18,100, has been running since early last year, but no operating results have yet been published. Service test results for the Brown Boveri locomotive, No. 18,000, which has been operating about two years longer, were published in The Engineer, May 16, 1952. These results showed a " tractor efficiency " averaging for four runs 7·66 per cent, based on the work done at the drawbar and the heavy fuel used under power, or 7·39 per cent on the basis of the work done at the drawbar and the total of heavy and light fuel used. The explanation of the two values of oil consumption is that a small gas-oil-burning auxiliary diesel is employed which runs continuously to supply auxiliary power and is used also for manœuvring. The turbine is also started on gas oil. The gas oil consumption is about 3·7 per cent of that used under power, or about 4 per cent including idling. If we include idling consumption the efficiency falls to 6·6 per cent. Such efficiencies are only of the same order as the best obtainable with steam and must have seemed disappointing to a public which has been led to expect the gas turbine to effect a revolutionary advance. It is accordingly pertinent to analyse them so far as the data allow, to see whether the performance is really below what was to be expected, and whether it is likely to be improved on by locomotive No. 18,100.

In the first place, the Brown Boveri gas turbine was understood to be in major essentials practically a repeat of that supplied to the Swiss Federal Railways in 1941, though rated a little higher and possibly slightly trimmed to fit our smaller structure gauge. When works-tested before dispatch it is understood to have shown, at full load of about 2500 h.p., approximately the guaranteed efficiency of 16·8 per cent at the coupling with a turbine inlet temperature of about 1100 deg. Fah. Hence, there is good reason to believe that the power unit was in accordance with design expectations. Secondly, the " tractor efficiency " of 7·39 per cent is not, of course, the same thing as the thermal efficiency of the engine, though it is referred to as " overall thermal efficiency " by locomotive men. This nomenclature is unfortunate and has led to widespread misunderstanding among both the public and engineers. It is responsible for the erroneous though widely held notion that the orthodox steam locomotive is so bad that it should readily be possible to produce something much better, whereas in fact there is still no generally satisfactory alternative in sight despite the efforts of inventors and innovators. The drawbar horsepower is a concept useful to the railway man, but gives no credit for the energy expended in overcoming the head resistance of the train or the rolling resistance of the locomotive itself. These figures are difficult to obtain with orthodox locomotives since the indicated horsepower includes also losses in internal mechanical inefficiency. With electric drive, observation of volts and amperes would, with known inefficiency of motors and gears, have allowed the power at the wheel to be obtained, but such data are not included in the published results of the trials. However, an article by E. C. Poultney in The Engineer, July 18, 1952, page 102, suggested that the additional " frictional " horsepower might be 279. Other tests on steam locomotives suggest a rather higher figure. Using Mr. Poultney's estimate we find that the horsepower utilised was not an average of 754, but of 1033. Hence, the thermal efficiency at the wheel, based on total consumption of fuel, becomes about 10 per cent instead of 7·39 per cent. (A similar correction applies naturally to the usual efficiencies quoted for steam locomotives also.)

Now 10 per cent efficiency, though not so bad, still seems poor compared with 16·8 per cent. It is, however, necessary to remember that 16·8 per cent applies at the turbine coupling whereas 10 per cent is at the wheel. There are generator losses of the order of, say, 3 per cent at this load, and motor and gear losses which may be of the order of 14 per cent, giving about 83 per cent transmission efficiency, so that 10 per cent at the wheel is really equivalent to about 12 per cent at the turbine coupling. Further, the guaranteed efficiency would be based on the net calorific value of the fuel in accordance with ordinary practice for oil, whereas the service results were based on the gross as is usual for coal. This makes a difference of the order of 6 per cent, giving 12·7 per cent efficiency at the coupling on the net c.v. What, then, explains the difference between 12·7 per cent realised and 16·8 per cent shown in the works test at full load ? In this connection



Test points at 1500 h.p. and 3000 h.p. relate to Curve *c*. The other test point, marked by arrow, relates to Curve *b*.

Comparison of Locomotive Gas Turbine Efficiencies

the diagram is of interest. It shows at *b* the efficiency characteristic of the turbine published in the Railway Executive's report. Curve *a* shown for comparison is the corresponding characteristic of the Swiss Federal Railways turbine, tests on which were carried out by the Swiss Association of Steam Boiler Owners and published in *I.Mech.E. Proceedings*, 1943, Vol. 150, page 1. Neither test states the temperature or the speed of the turbine,

but it can be assumed that in the Swiss test, since the makers were present, the speed was continually adjusted to the optimum within the permitted limits of temperature. Unlike a gas turbine designed for the drive of an alternator the load on the traction gas turbine does not show a unique relation between load and temperature, unless the speed is defined. Thus it is possible to obtain a variety of efficiencies at each load, the best being that which uses the lowest speed and, hence, the rated turbine temperature or the highest temperature permitted by surging considerations in the compressor. The marked difference between curves *a* and *b* seems to call for explanation. Clearly *a* is much to be preferred to *b* for general purposes, while the works test point seems to bear no relation to characteristic *b*. Possible factors which could account for the changes are differences in specification, partially fouled state of the machine at the time or failure to adjust to the optimum speed, i.e. to utilise the highest permissible temperature. It is not possible to draw any definite deduction, but the last seems to be the most likely. Fouling might explain the full output not being obtained and the works test point being so far removed from the characteristic, but it seems unlikely that it could alone alter the entire shape. The fact that the efficiency obtained in service during the road trials (12 per cent on gross c.v.) was better than the figure of 11 per cent of curve *b* at the average load of 1000 h.p. cannot be taken as evidence as to whether the same conditions then applied. (The average efficiency over a variety of loads will not necessarily be the efficiency at the average load.) The question therefore remains open as to whether the load/speed relation, i.e. in effect the fuel/air ratio, was correctly set during the trials so as to get the best thermal efficiency, and accordingly whether this locomotive has yet shown as good a fuel consumption as it is capable of. If it could be adjusted to give the characteristic *a* in place of *b*, then the consumption in service (because this involves running mainly at loads of the order of 1000 h.p.) would be improved by approximately 40 per cent. This is significant because it is roughly the ratio by which the gas turbine locomotive falls short of equality in running cost with steam. The comparison shown by Mr. Poultney gave 2·05 lb of oil consumed per drawbar horsepower-hour by the gas turbine locomotive against 3·74 lb of coal for the steam locomotive. We ignore correction to the same drawbar horsepower, since we do not know what correction to apply to steam. Allowing likely figures for the respective calorific values the ratio of heat consumptions is then $2{\cdot}05 \times 18{,}500 \div 3{\cdot}74 \times 14{,}000 = 0{\cdot}72$. But assuming London prices of about £12 per ton for heavy oil and, say, £4 10s. per ton for locomotive coal, the running cost ratio is 1·45. This running cost ratio is probably such as to put the gas turbine locomotive out of court as a serious competitor with steam, since in main line service savings in banking and standing losses could hardly compensate for this extra cost. If, however, the fuel rate could be improved as above mentioned so as to obtain the curve *a* instead of *b*, then the gas turbine would be roughly on a par for fuel cost when actually running and would benefit from lower standing consumption, and might prove to have other advantages to justify its much higher capital cost.

The next question which naturally arises is what sort of showing the "Metrovick" locomotive is likely to be making in comparison. The only available data at present is that published in the manufacturer's house ournal after the shop tests. From these curve *c* is deduced, on which there are only two points, corresponding to half load 1500 h.p., and full load, 3000 h.p., respectively. The full load point is assumed to be 3000 h.p., giving an efficiency of 19 per cent at the coupling. (Consumption 0·88 lb per horsepower-hour at wheel.) The half load efficiency is derived from the statement that the half load fuel rate will be 1·3 lb per horsepower-hour. It is assumed that the efficiency of motors, gears and generator is substantially the same at half load as at full load (actually it must vary at any load with speed and drawbar pull). The curve is likely to be nearly straight between the two points, any concavity being downward. Hence the lower part of the curve must apparently follow the trend indicated, or an even steeper one. It seems, therefore, fair to expect that there will be no significant difference at 1000 h.p. between efficiencies *b* and *c*. The "Metrovick" locomotive, in other words, though designed for high temperature, will not be able to use it most of the time and will suffer from the absence of a regenerator which can be markedly helpful at fractional load even though possibly contributing no net advantage at full load. Thus, if the "Metrovick" locomotive operates on the same schedule as the Brown Boveri locomotive involving an average load of the order of 1000 h.p., it may be expected to show substantially the same consumption. As, however, it will burn entirely gas oil at a price possibly as much as £4 per ton higher, its running cost for fuel will be greater by roughly 30 per cent—that is, 80 per cent more than for a coal-fired locomotive in the same service. Thus the future of the oil-burning gas turbine locomotive based on the performance of either of these trial designs does not seem particularly rosy. It is also worth remembering that the cost of a gas turbine locomotive is as much as three to four times that of the steam locomotive, and to justify this it would need to be in operation during a much larger fraction of the total time—that is to say, the gas turbine locomotive would have to run something like 250,000 miles per annum, e.g. from London to Glasgow and back every twenty-four hours on 300 days in the year. Such a schedule calls for high reliability and organisation and may be outside the capability of the locomotives as at present built. It is, nevertheless, required of diesel locomotives in the U.S.A. and, with proper organisation of a large fleet, is made possible by carrying out overhauls and replacements during the short standing time between runs. Full utilisation involves, of course, refuelling and check over, at or near the departure platform and may call for some indulgence in the interpretation of trade union rules.

Incidentally, the diesel locomotive appears still to be in the running as a possible competitor with the orthodox steam locomotive. A few figures are available from trials of British equipment and they are in line with those based on more comprehensive operating experience in France. According to tests on the Chaumont–Basle line in 1946–47, a Swiss-built diesel showed a consumption per ton-mile about one-third of that of the S.F.R. gas turbine locomotive when hauling similar trains to the same schedule. The fuel cost of the diesel would accordingly be about 0·6 of that of a steam locomotive based on the above figures. To this may be added, say, 10 per cent for the cost of lubricating oil, leaving the diesel still much the most economical of the three types, as the summary in the table below shows. This is valid for the London area, but the advantage may almost disappear near the coalfields and remote from main ports.

Gas Turbine Locomotive Comparisons

	Steam	Diesel-electric	Gas turbine electric	
			M.V.	Brown-Boveri
Thermal efficiency at best load :				
At coupling	12·7*	34	19	16·8
At wheel	11	28	16	14·3
Tractor, i.e. "drawbar" efficiency, in service	5·2†	18·2‡	6·6§	6·6
Fuel	Coal	Gas oil	Gas oil	Heavy oil
Price, (£) per ton	4·5	16	16	12‖
Pounds fuel per 1000 ton-miles hauled	120	24	66	66
B.Th.U. per pound	13,000	19,000	19,000	18,500
B.Th.U. per ton-mile	1,560	456	1,250	1,250
Fuel cost per 1000 ton-miles hauled, (£)	0·24	0·17 (+10%)	0·47	0·36

* Indicated at 1000 h.p. on "Hall" class.
† Better figures up to 7·5 per cent have been recorded on test runs.
‡ French figures.
§ Estimated (see text).
‖ Correction of about 1½ per cent for gas oil ignored.

Consideration of Redesign

In the light of the foregoing it appears that the deficiency of the gas turbine locomotives is not to be attributed to the gas turbines *per se*, but to other factors: in the one case (subject to caveat) apparent maladjustment, and in the other unsuitable rating having regard to the duty and the characteristic. As an observant civil servant put it :

> "The best laid schemes o' mice and men
> gang aft agley."

One of the failings of the gas turbine is its propensity for "agley ganging." This is in part the consequence of the recirculation of power and will become less marked as the initial temperature can be raised. At present the penalty for misjudgment, either of the load or of any component, or of maladjustment, is serious. It is understandable that the operating staff should view with some respect temperatures of the order of 1100 deg. Fah. and prefer to operate with lower ones if given any scope. The serious effect on performance might not be immediately appreciated. It is also to be remarked that in steam locomotives a running performance considerably below the best attainable is accepted as usual. Railway executives, because of their experience with steam where bad coal or poor firing can greatly reduce the output (which can in any case be fully developed only at high speed), have been mainly interested in the full power duty, whereas it can now be seen they should have paid much more attention to the efficiency at about 1000 h.p. and less. It also appears that in designing for 3500 h.p. Metropolitan-Vickers erred on the wrong side. An even lower rating than the original Swiss locomotive would have given a better all-round performance. It is understood that the possible export market influenced the choice. In this connection it may be remarked that about 4000 to 4800 h.p. is thought the right choice in the U.S.A., where, however, trains are much heavier, up to 4500 tons against our more usual 500. So by analogy something less than 2000 h.p. ought to be chosen here. The better utilisation of the gas turbine locomotives in the U.S.A. is brought out in their operating results, which over about 100,000 miles in mainly freight service showed a consumption of 4·9 U.S. gallons per 1000 gross ton-miles, and an average load of

3640 tons (all assumed to be short tons of 2000 lb). This is equivalent in the units of the table given above to about 48 lb per 1000 ton-miles hauled (c.f. 66). It is not, however, fair to compare directly these figures since the resistance per ton will not be the same: it will in fact be lower for the heavy goods trains in the U.S.A. All we can deduce therefore, is that the operating efficiency of the pilot GE-Alco locomotive was less than 9 per cent at the drawbar on the average. The last test (before its removal from service) with more suitable trains, averaging 3810 tons, led to a consumption of 3·51 U.S. gallons per 1000 gross ton miles. This we can say represents an efficiency of something less than 12 per cent in comparison with the efficiency at turbine coupling of about 17 per cent. The six service models now in operation are stated to be showing an average consumption of about 4·28 U.S. gallons per 1000 gross ton miles, hauling heavy trains on a mountainous section.

Much prestige also seems to have been attached to ability to climb a stiff bank occasionally at high speed with a large load, though it is questionable how far it was worth while to sacrifice normal running economy for the sake of such performance, however impressive to railway enthusiasts. Profiting now by what we all know and what should have been clear to experts from the beginning, it is clear that if the gas turbine locomotives were to be designed again, consideration might be given to installing less nominal horsepower, making use of a higher temperature for the occasional peak duty or even to equipping them with two units of half capacity as in the case of one U.S.A. model, so that in normal service one unit would be shut down and the other run at about its optimum efficiency. This would amount to carrying 100 per cent spare capacity to be used once or twice per day for a few minutes on possibly a few months of the year, when climbing a steep gradient in hot weather with an extra heavy train, or when required to start away on a steep gradient after an unscheduled stop. While duplication of the power plant would confer some advantage in reliability it may be questioned whether carrying round unnecessary plant could really be justified, or whether it would not be more economical to have two separate locomotives of half rating even though they might need to be assisted on steep banks. It will be recalled that at least one of our railways was laid out by the far-sighted Brunel so as to provide easy gradients over the greater part of the route and to concentrate the steep rises at one or two places where assistance could readily be given. The prospect of a crackerjack new type being assisted up a steep hill by a steam locomotive pushing behind may seem undignified, but dignity may be a luxury the railways can no longer afford. Though one would not expect to get two half-duty locomotives for the price of one of full duty, nevertheless there would be considerable saving in price and weight and, therefore, of parasitic rolling resistance by halving the rated power. No doubt such a light locomotive would require to use all its wheels for driving and conceivably might have to accept a higher gear ratio in order to obtain maximum starting tractive effort, but this might also be a reasonable compromise since it appears that the top speed of the existing locomotives is rarely, if ever, to be used.

It may be hoped that there is time for the designers of the British coal-fired gas turbine locomotive to profit by the experience with the oil-fired one by designing for the best performance at half load or below. This seems to be possible because, although the drive is direct mechanical, it will be from a separate power turbine, and the speed of the gas generator element will therefore be variable, permitting of reduced air rate at fractional loads. There will also be what amounts to a regenerator following the coal-fired air heater and thus it should be possible to obtain a characteristic of the type *a* already discussed. Moreover, on coal an efficiency considerably below that obtained with oil will still put the gas turbine in a favourable position on running cost. On the other hand, in order to retain a true perspective it must be realised that in building oil-fired gas turbines manufacturers were following an already trodden path, the difficulties of which were more or less charted, whereas in tackling the use of coal, even in an indirectly fired circuit, they are entering a field which is largely new where the difficulties can only be surmised and unforeseen ones are liable to be encountered. The development of a satisfactory combustion equipment, especially in a locomotive, is not a process which can be carried out on paper or by small-scale tests. It is likely to involve cut-and-try methods which tend to be slower and more expensive than contemplated, as has been found, for instance, in the U.S.A. direct coal-fired gas turbine project. No quick results with the coal-fired gas turbine locomotive are therefore to be awaited, though it is fair to expect that the difficulties of the indirectly fired system will be less awesome than in the direct-fired case.

Power Station Plant

In the power station field the first British set to be installed by a purchaser had its first run in August. It is the 15MW set built by Metropolitan-Vickers Electrical Co., Ltd., to the order of the former Stretford and District Electricity Board and installed in Trafford power station, now taken over by the British Electricity Authority. It is one of the three large sets ordered in 1947. The other two at Dunston and Dundee are understood to be in erection, but unlikely to run for several months. The Trafford gas turbine appears to have done little serious running so far, and has not yet been on full load, but it should be understood that it was not assembled and run in the works, this being dispensed with since the power station is within a short distance. The somewhat protracted preliminary site testing must accordingly be regarded as taking the place of the investigational running which would ordinarily be done on the maker's test bed, and which is naturally carried out somewhat cautiously in the first machine of its type. Accordingly, it is too early to make any useful comment on the general position, though the overriding limitations of high fuel cost already referred to cannot be evaded. All the three power station trial plants can thus be regarded as providing mainly experience intended to lead to something else, e.g. to export work or to quick starting emergency or peak load units, or even to coal-fired machines.

The Gas-Turbine Ship

Though there is as yet no ship driven exclusively by gas turbines, the Anglo-Saxon Petroleum Company's 12,000-ton tanker "Auris" has now been at sea for over a year with the B.T.H. 1200 h.p. gas turbo-alternator installed in place of one of its original four diesel engines. A recent report, after 53,000 miles with 40 per cent of the power supplied by the gas turbine, states that its performance was extremely reliable and that the consumption of fuel was about that of a steam turbine. This gas turbine can therefore be regarded as a success since no more was to be expected in so small a unit. For much of the time the gas turbine operated on diesel oil, but more recently on a fairly heavy oil of 1500 seconds Redwood. It now appears that as a result some of the turbine blades are showing vanadium attack, and they will have to be be replaced with Nimonic. The main advantage of the gas turbine would appear to be the small amount of maintenance and attendance it requires at sea and in port, and it is understood that the owners are to order a larger tanker with 8300 h.p. of gas turbines.

The reason why the gas turbine can be competitive at sea and not on land is primarily that at sea oil is practically the only fuel to be considered, coal not being a serious competitor. On the other hand, to the merchant ship fuel cost has generally been held to be of paramount importance because a ship operates almost continuously and a consumption of the order of 20 tons per day at, say, £8 to £12 per ton represents the largest single item in the cost of running. It may at first sight seem surprising, therefore, that the gas turbine with a best efficiency on test of, say, 22 per cent, can compete with the diesel engine with an efficiency of, say, 34 per cent. (In actual service the gas turbine has shown a fuel consumption of 0·75 lb/b.h.p.-hr., equivalent to a running efficiency of about 18·5 per cent, but the best diesel efficiency would also need to be somewhat discounted for average conditions.) The explanation lies presumably in the relative costs of furnace oil and diesel oil at most ports which can be taken in round figures to be £8 and £12 per ton respectively. Thus an efficiency of 22·7 per cent for the gas turbine is approximately equivalent in fuel cost to 34 per cent in the diesel. In addition, the diesel will consume more lubricating oil which might be assumed equivalent to at least 5 per cent extra fuel cost, which makes 22 per cent rather better than equivalent. The diesel also requires a great deal more maintenance in port. Against this, however, may be mentioned that quite 300 diesel-engined ships are operating successfully on boiler oil, many of them by the same owner (though mainly with low-speed diesel engines). The present advantage of the gas turbine for mercantile marine purposes is accordingly somewhat slender and precarious, though it is reasonable to expect the position to improve with the use of units of larger rating (which would raise the test efficiency to the order of 24 per cent) and possibly in time the employment of higher temperatures, since, if special materials have to be used against corrosion, it will be logical to make fuller use of their higher heat resistance.

General Assessment

From the foregoing we can conclude that for ordinary use in this country the gas-oil-fired power station gas turbine is not expected to compete in its present forms with coal-fired steam plant in normal sizes, and the oil-burning gas turbine locomotives unless redesigned to a different compromise between output and efficiency cannot be regarded as any immediate threat to the existing steam locomotive. On the other hand, in the marine field, not only is there a great interest in naval applications, but also the rather small-scale experiment carried out by private enterprise seems likely to lead to further and larger installations on the same lines, with a prospect of something of solid value.

This appraisal of the situation, though it may come as a shock to the public and to engineers not intimately familiar with the matter, who have come to regard the gas turbine as having some special magic, contains, of course, nothing new. It has

been fairly clear to those in a position to assess the present capabilities and limitations of the gas turbine in its different forms and in its various fields that any immediate applicability lies not in the field of ordinary large-scale prime movers such as electric power generation, but in such specialised duties as supplementing hydraulic power in droughts, oil field power generation using natural gas, pipeline pumping, emergency and peak load duties of extraordinary low load factor burning oil, or for special military purposes, particularly where portability is important. It is presumably through a realisation of these limitations that the Ministry of Fuel and Power has transferred its promotional activities to the burning of indigenous fuels, coal, peat and methane. These, however, are to be regarded as long-range investigations and a stage behind oil and gas firing in that when their feasibility has been fully established by present experimental plants their economic importance will remain to be proven. In particular, it may be mentioned that the technical successes recently announced in burning peat in both open and closed circuit units do not imply that peat-burning plant will necessarily be commercially attractive in a coal-producing country, or even in one with water power.

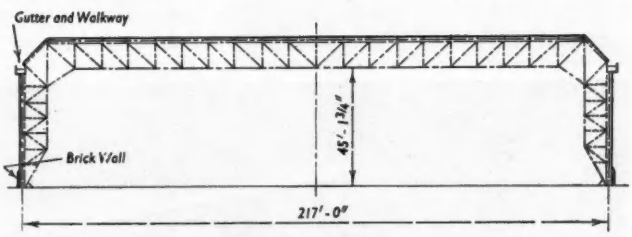
One sobering point which the results of trials may bring home is the necessity for adequately discounting paper calculations and even short period test performances, since in normal service plant can rarely be supervised so carefully as in tests, nor can it ordinarily be made so that its performance is insensitive to the handling it gets. As already mentioned, no variation from expected conditions will improve the optimum performance—that can only deteriorate. A concept familiar to practical engineers is "operating loss." This is not a true loss, but is a convenient way of assessing the ratio of the annual performance in service to the test performance over a few hours. It allows for such things as fouling, load variations, temperature variations, &c., and though attempts have been made to correlate it with load factor there is little such correlation. Suffice it to say that very few steam plants ever attain an annual performance anywhere near their prospective capability and if they do the figures are quite rightly viewed with a certain suspicion.

It has not been usual among the gas turbine fraternity to allow that any discount of design figures is necessary. The test or guaranteed efficiency (on the lower calorific value) tends to be compared with actual performances of steam power stations over a year (on the higher calorific value). Even worse blunders have been made. Thus, the gas turbine locomotive has been credited with its best load prospective coupling efficiency of 25 per cent (so far merely a paper figure) in comparison with the 5 per cent actually attained in service at the drawbar by steam locomotives which is by no means the highest figure which has been obtained. Trials are an expensive way of dealing with misconceptions of this sort, though they are essential to discover the order of the operating loss since that cannot be estimated from first principles.

A 200ft Span Aluminium Hangar

An impressive example of the structural use of aluminium alloy is provided by the hangar now nearing completion at the premises of the de Havilland Aircraft Company at Hatfield. The hangar consists of a series of braced portal frames, each with a clear span of 200ft, and covers 66,000 square feet. It is claimed to be competitive in cost with the various alternative designs, using other materials, which were considered.

IN our issue of June 1, 1951, a description was given of three aluminium hangars which were, at that time, under construction at London Airport. Structurally, each of these three hangars consisted of braced two-pinned portal frames spanning nearly 150ft, and they were believed to be the first hangars to be built entirely of aluminium alloy. With the experience gained with these structures a somewhat similar but more ambitious design was adopted for a hangar to be built at the aerodrome of the de Havilland Aircraft Company at Hatfield. This hangar is now virtually complete from the point of view of the aluminium structure, although the annexe buildings to be erected along the west side of it are still in a fairly early stage of construction; it is to be used as a flight hangar for "Comet" aircraft.



Hangar Portal Frame

The accompanying illustrations give a general idea of the structural design and the erection of the hangar. The main structure consists of twelve aluminium alloy portal frames at 30ft centres, spanning 217ft between pinned bases and giving a clear floor area 200ft wide by 330ft long, with a clear height of 45ft. The roof is of north light construction with aluminium roof decking covered with bitumen felt, the glazing being fixed with aluminium glazing bars. The east side is sheeted with corrugated aluminium sheeting lined with insulating board and aluminium foil insulation, and the west side abuts the annexe building, which incorporates a control tower at the south-west corner. The north and south ends are fitted with doors, each giving a clear opening 200ft wide by 45ft high.

The building stands on a substantial concrete raft, which brings the floor level up to that of other buildings nearby. The portal frame bases are each secured to the foundation blocks by four 2in diameter holding-down bolts designed to resist shear and uplift. One illustration overleaf shows a portal base in detail, and it is not without interest to note that the base and the bottom gusset of the portal leg are of fabricated steel, as compared with the aluminium castings used for the portal bases of the hangar at London Airport. The aluminium structural members bolted into the steel gusset can be clearly seen in the illustrations. The side thrust of the portal frames is taken up without spread by 18in by 18in prestressed concrete tie beams, prestressed using the Freyssinet system, as our third illustration shows.

The various alloys used and the quantities of the different materials involved are listed in the accompanying table. The various shop connections were riveted with ⅞in to ¾in diameter rivets of NE5, NE6 or similar alloy, the rivets being closed cold by squeeze or percussion riveters. Site connections were made with Sheradized turned and fitted steel bolts, and spun galvanised black steel bolts.

The loading conditions were in accordance with those stipulated in B.S. 449 : 1948. In addition to dead loads from the covering and structure, a snow load of 10 lb per square foot was taken, and to allow for the addition of lights, sprinkler systems, &c., an extra load of 2 lb per square foot was allowed. The main portal frames were also designed to withstand 30-cwt point loads at four positions along the lower boom to allow for a light runway being added. Wind forces were based on a wind velocity of 65 m.p.h. at an effective height of 50ft, resulting in a pressure of 14 lb per square foot.

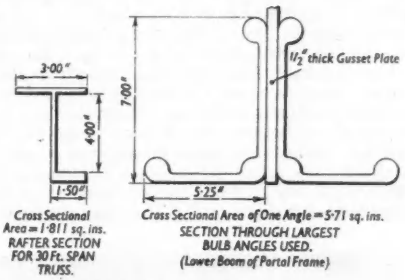
Hangar Materials

	Aluminium, tons	Other materials, tons
Weights :		
Structural sections	106	—
Plate	40	—
Sheeting	10	—
Roof decking	40	125
Glazing	4	28
Lining	—	11
Steel components	—	31
	200	195

Total weight 395 tons. Weight per square foot 12½ lb.

Alloys used :
- Structural sections ... B.S. 1476/H.E. 10 W.P.
- Gusset plates ... ... B.S. 1477/H.P. 10 W.P.
- Sheeting ... ... B.S. 1470/N.S.3. ¾ H.

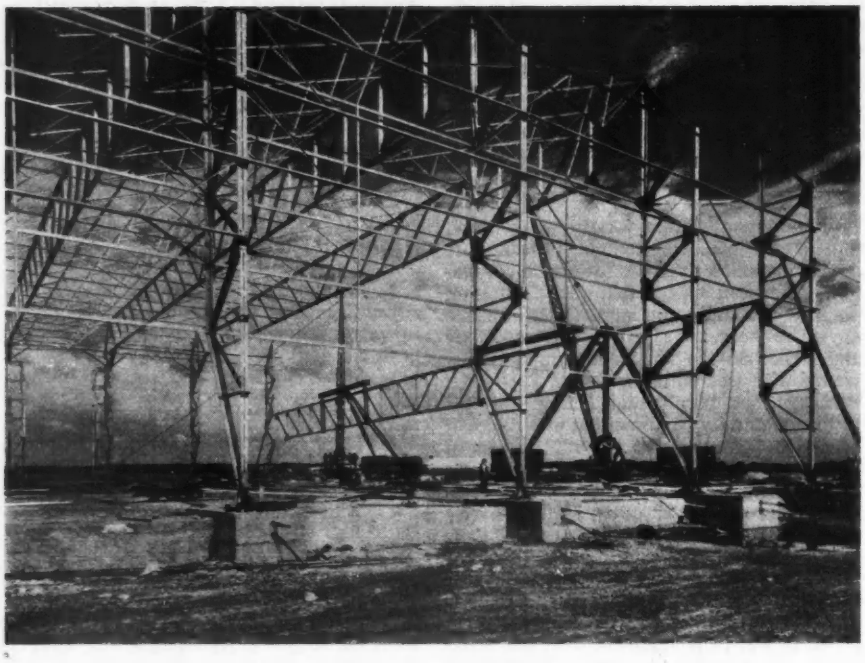
The legs of the portals are 8ft wide and the horizontal girder portions have a constant depth of 10ft throughout their span, except for a a greater depth at knee positions to counteract the heavy fixing couples induced. The clear height to the underside of the booms under the severest loading conditions is 45ft 1½in. The primary and secondary members of these frames consist of double bulb angles, designed so that there is no danger of torsional failure at a lower load than that at which flexural failure would normally occur. Battened channel construction was employed for the hangars at London Airport, but it has been found that the use of double angles results in a considerable saving of man-hours during fabrication. Connections are made with ⅞in or ¾in thick gusset plates.


3·00"
4·00"
1·50"
7·00"
½" thick Gusset Plate
5·25"
Cross Sectional Area = 1·811 sq. ins.
RAFTER SECTION FOR 30 Ft. SPAN TRUSS.
Cross Sectional Area of One Angle = 5·71 sq. ins.
SECTION THROUGH LARGEST BULB ANGLES USED.
(Lower Boom of Portal Frame)

Typical Structural Sections

The upper and lower booms of the portals are stabilised by saw tooth trusses spanning between node points at 10ft centres. The portal legs are stabilised on the east side by using stayed sheeting rails; the stays spring from the inner legs of the portals, and have the effect of reducing the section required for the sheeting rails. Any unbalanced load is taken by ties running horizontally between the inner legs, the end bays being fully trussed between the corresponding tie and sheeting rail. This method of stabilisation is shown in the foreground of our third illustration. It could not be repeated on the west side, as large openings were required there to give access to the annexe building. The portal legs on this side were therefore stabilised by the addition of a vertical frame running parallel with the leg, and two other frames at right angles to the leg, thus forming a boxed structure, as shown in the background of the same illustration. Each portal weighs only 6 tons 7 cwt.

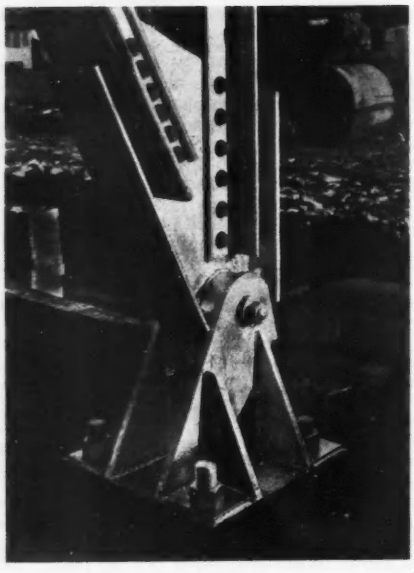
The saw tooth trusses were designed for simple fabrication and each consists of a rafter, a horizontal tie, a queen tie and two internal struts. The rafter is in the form of a 4in channel with an additional flange, the clear web obviating the



Erection of Portal Frames

necessity for gusset plates for internal members in the majority of the trusses, the members being riveted directly to the web. Lateral stability is provided by two ties at rafter level and one at truss tie level. The roof decking is bolted directly to the top flange of the rafter section. The hip slopes in each bay are supported by purlins which span between the hip trusses and the sloping shoulders of the portal frames. The hip truss spans between the second node of one portal and the first node on the adjacent portal.

Each truss rafter is fitted with a framed stool to which is attached one side of the valley gutter and the lower glazing rail. The glazing astragals



Pinned Base of Portal Frame

span between this rail and cleats riveted to the upper boom of the portal frames at 2ft centres. There are twenty-three trusses to each bay, making 253 in all. Each truss weighs 175 lb.

Wind girders are introduced in the end bays of the structure between the last three portals. Canopy frames are fitted to the north and south end portal frames. The steel upper guide channels for the doors are incorporated in the canopies and are supported by wind girder members at 10ft centres, produced beyond the last line of portals. The underside of each canopy is sheeted with 16 S.W.G. aluminium alloy sheeting, level with the lower flanges of the guide channels, thus providing a flat surface for the rubber draught excluder along the upper edge of the sliding and folding doors.

The problem of expansion along the 330ft length of the hangar was solved by introducing expansion joints at all structural connections on one side of the sixth portal frame from the north end. The truss shoes at this position are connected to the portal frame by short links which are free to swing in an arc. This has necessitated using a special cast shoe on each truss along this bay, in place of the usual gusset plate. All sheeting rails and ties on the east side have slotted holes at this position, the rail stays being formed in such a manner as to allow freedom for expansion and still to function as stabilisers for the portal leg. Expansion in the width of the building is absorbed by strain in the portal frame members.

The north-light roof has eleven valleys and twelve continuous runs of glazing, 9ft 3in deep. The south slopes are covered with Briggs aluminium roof decking covered on the outside with ½in insulation board, bonded to the deeply corrugated decking with hot oxidised bitumen, the whole being waterproofed with two layers of bitumen roofing felt with mineral finish to the capping sheet. The hip slopes are covered in the same way. The valley gutters spill over these slopes into 2ft wide boundary wall gutters which run the full length of the sides, widening at each corner to form 10ft by 12ft platforms, and are then continued along the ends. They are fitted with aluminium handrails so that they may be used as walkways. The gutters are drained by six 4½in diameter aluminium alloy downpipes. Canopies are provided over the main doors, the north canopy being glazed and the south covered with Briggs decking.

The east wall is sheeted with corrugated aluminium alloy sheeting treated by the Alochrome process. This wall is lined with $\frac{1}{16}$in thick asbestos-wood board and Sunfoil reflective insulation fixed by extruded aluminium "T" sections. The bottom 9ft 4in of the wall is of brick. The west wall is sheeted only above the roof level of the annexe. The main sliding and folding Esavian doors give a clear opening 200ft wide by 44ft 9in high. Two sliding and folding doors, 12ft wide and 15ft high, are incorporated in the east wall.

Erection

Erection of the portal frames was given careful consideration. So as to obviate any undue lateral distortion the vertical legs of two frames were first erected and braced together laterally and in the plane of each frame, whilst one roof girder was lifted into position by slings from four points about 40ft apart, each pair of slings being suspended from lifting beams, as shown in the illustration on this page. Although the weight of the roof girder is only about 4·5 tons, two 5-ton hand cranes were used to provide the 60ft length of jib required for the operation. Whilst the vertical legs were being erected the roof girder was assembled in two halves. The two assemblies were then brought together along the centre line of the portal frame, mated and then lifted into position. The assembly took only two days per frame, and the lifting operation was completed in three hours.

Following the erection of two frames, the roof trusses were then hoisted into position by hand, using light tackle rigged from the portals, which were held in position by the cranes until sufficient trusses were connected to give lateral support to the portal frames. Longitudinal ties, bracing members and glazing purlins were then fixed by hand. Erection of the complete structure was completed by eighteen men in thirteen weeks.

The main structural contractor for the hangar was Structural and Mechanical Development Engineers, Ltd., of Slough, which firm also designed the aluminium structure. Erection of this structure was carried out by Carter Horseley (Engineers), Ltd. The consulting engineer for the foundations was Mr. J. Bak, and the foundation contractor Gilbert Ash, Ltd.; the architects were Messrs. James Monro and Son.

It is pointed out by the main contractor that aluminium was chosen for this structure because

200ft Span Aluminium Hangar

of the economic advantage it offered in relation to other materials. In a span of the width considered here the weight was about one-seventh of that of an equivalent steel structure. The well-known advantages of aluminium construction, such as ease of erection and freedom from corrosion, were again evident with this structure. We understand that availability of the material was also a factor in favour of the use of aluminium. The structure was first considered, and designs prepared, about a year ago.

Bursting Disc Design and Application in the Chemical Industry*

By D. J. BREEZE B.Sc.†

THERE are several ways of protecting a vessel against pressures greater than that for which it has been designed. One of the most usual devices for this purpose is the relief valve, but this has characteristics which render its use without other safeguards inadvisable in some cases.

(*a*) It is not completely foolproof. Typical causes of relief valve breakdown are corrosion, gumming up of the mechanism by deposited solids, and unauthorised tampering with the setting.

(*b*) It has a certain amount of inertia, and may not respond rapidly enough to a sudden pressure surge. It is useless for protecting a vessel against the effects of an explosion.

Largely because of these disadvantages, a good deal of thought has been given to the employment of thin membranes as protective devices on pressure vessels. These devices, called bursting discs or rupture discs, are now widely used in the oil refining and chemical industries, particularly in America.

A properly designed bursting disc can be guaranteed to burst at a pressure not exceeding a stated maximum. It has very little inertia, and on failure provides an unobstructed opening for relief of pressure. It can often be used for protecting equipment subject to explosions. Corrosion or excessive temperature invariably weakens a disc ; this is no disadvantage from the point of view of safety. A bursting disc can be installed in such a manner that it is very difficult for an unauthorised person to tamper with it. There are many applications in the chemical industry where a bursting disc, used either alone, in parallel with or in series with a relief valve, can provide greater protection against excessive pressure than a relief valve alone. Nevertheless, it must be stressed that bursting discs are seldom used where a relief valve can provide adequate protection, and in many cases provision of a relief valve is statutory.

Two main types of disc are used, flat and predished. The flat bursting disc is a flat circular sheet of thin material mounted between two flanges on the item of equipment being protected. Sometimes a compound assembly is used, made up of more than one disc. The discs in the compound assembly may or not be of the same material. An instance of this would be a disc with suitable bursting pressure characteristics protected against corrosion by a second disc which, though resistant to corrosion, is too weak on its own. The flat discs may or may not dish under the normal working pressure in the equipment.

Predished discs, as their name suggests, are discs which are dished before use. As a general rule they are more reliable than flat discs.

Flat bursting discs are often made on site, but it is usual for predished discs to be obtained from suppliers.

Design of Disc Mountings

Bursting discs, whether flat or dished, are best secured between special flanges. These are machined so that the disc fits snugly between them and are usually radiused to accommodate dishing of the disc (Fig. 1) The flanges sometimes form part of the pipework or may be separate. Where separate flanges are used, the assembly of bursting disc plus flanges is bolted between two drilled flanges. It is very important to avoid weakening the disc during assembly, either by bad alignment or by uneven pulling down of bolts. Excessive bolt pressure could cut the disc, and the final tightening down is sometimes left until the vessel is under pressure, when just sufficient adjustment is made to avoid leakage at the disc.

Care is required in the design of the mounting. All bursting discs have a limited life, which in some cases may be only a few days. It is necessary, therefore, to ensure that discs can be replaced quickly without undue effort or loss of time. If the vented fluids are harmless and may

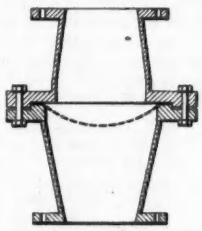


Fig. 1—Bursting Disc Flanges

be discharged directly to atmosphere, the rupture disc is mounted on a branch of the vessel without a vent stack, so that replacement is a simple matter. Frequently, however, the vented fluids must be conveyed away from the vessel to a safe point of discharge, sometimes through a surge tank if hazardous or expensive liquids have to be trapped. If the rupture disc is a small one, the pipe flanges may be sprung apart to permit disc replacements, or a short section of the vent piping above the disc can be made removable. For larger discs, it is customary to provide some means of raising the vent piping, e.g. screw jacks or counterweights. An alternative arrangement, sometimes used with bursting discs installed to relieve explosions, is to make the main vent piping rigid and provide a short stack above the disc which telescopes into the piping.

Where the disc must be enclosed and requires frequent inspection or changing, the best arrangement is to mount the disc inside an inspection box. The box shown in Fig. 2 has hinged doors

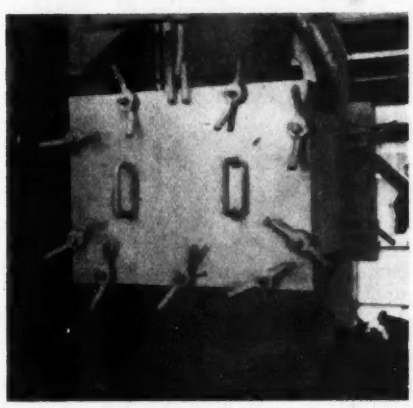


Fig. 2—Bursting Disc Box

fitted with winged nuts, providing easy access to the disc without the necessity for raising a heavy vent stack.

Bursting Disc Materials

Materials currently used for bursting discs are aluminium, Monel, silver, lead, copper, borosilicate glass, nickel and the combinations lead/rubber, aluminium/lead, aluminium/asbestos. The asbestos is a proprietary gasket material. The second material in each of the compound rupture discs acts as a protective medium for the first, which forms the actual bursting disc.

Of these materials, lead and glass are not really suitable, and can be used only where there is a wide margin between the design pressure of the vessel and its normal working pressure. This lessens the risk of premature disc failure which, for lead, may occur because of creep and fatigue, and for glass because of various factors, including variability in tensile strength. Aluminium sheet, 0·004in and 0·006in thick is purchased in rolls, and discs are cut from it on site as required. Sometimes it is used on its own, in single or double thickness ; occasionally, where the temperature is high or conditions are corrosive, the aluminium is protected on the underside by $\frac{1}{32}$in thick compressed asbestos jointing. It has not been possible yet to secure high-grade aluminium at a reasonable price, and the commercial grade purchased is somewhat variable in quality.

Where it is proposed to make the disc on site, data published in a paper by Lake and Inglis[1] is used as a rough guide in assessing the material and thickness. The minimum size of the disc will previously have been calculated in the usual manner to give adequate venting area. Trial discs are then cut and pressure tested with air, steam, or water for range of failure and also for fatigue resistance. This second test consists of submitting the disc to 75 per cent of its bursting pressure fifty times in succession, then determining the bursting pressure. Allowance is made for the temperature to which the disc will be subjected under operating conditions. Rise in temperature almost always weakens the disc. When a suitable disc or disc combination has been found, its performance under operating conditions is observed and a fair working life for the disc is established. When necessary the disc is replaced at regular intervals.

It is very important that all discs and materials, whatever the source, be tested in a systematic manner because it is difficult to secure bursting disc materials which conform to rigid mechanical and metallurgical specifications.

Care is taken to ensure that the disc application is always correct. One of the dangers associated with the use of bursting discs is their apparent simplicity. It is difficult to convince an untrained worker that the use of a bursting disc a few thousandths of an inch thicker than specification might wreck a vessel with, say, 2in thick walls. Even trained workers have been known to suggest the use of a double thickness of material after a succession of premature disc failures on an item of equipment. It is essential, therefore, that the distribution of discs remains with a responsible engineer, who must ensure that they are properly applied and that their function is fully understood.

Design of Vessels Protected by Bursting Discs

It is stated in British Standard Code 1500 : 1949 for fusion welded pressure vessels that the design pressure of a vessel protected by a directly mounted bursting disc is the pressure at which the disc is designed to burst. To this pressure shall be added any negative pressure due to vacuum which may act on the opposite side of the pressure wall. If the vessel is to operate at temperatures other than atmospheric the design of the vessel shall be checked for the operating temperature at which the bursting pressure of the disc is a maximum.

This last qualification is important. If the disc is designed to work at an elevated temperature, its bursting pressure at lower temperatures may be considerably higher. The vessel must be built to withstand the maximum bursting pressure of the disc at any stage of the operations, which may be higher than the designed bursting pressure of the disc under normal operating conditions.

The designer will be aware of the normal operating pressure in the vessel which he has to design. He must now consider what margin should be allowed between the normal working pressure and the designed bursting pressure of the disc. This margin must be sufficiently wide to avoid premature failure of the disc which may be weakened by fatigue or corrosion under operating conditions. Each application must be considered on its merits.

T. S. Murphy[2] suggests the following ratios of disc bursting pressure to operating pressure :—

(1) For fairly steady or non-pulsating service ...	1·5
(2) For mildly pulsating pressure...	1·75
(3) For highly pulsating pressure...	2·0

These figures are a rough guide, and may be compared with actual data quoted later in this paper.

As an example, consider a vessel which has to

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† Monsanto Chemicals, Ltd., Ruabon.

operate at 25 lb per square inch and 100 deg. Cent. The pressure is non-pulsating, and the designer allows for the installation of a bursting disc which will fail at 38 lb per square inch and 100 deg. Cent. The process is a batch one, and at the start of the operation the vessel has to be heated from 15 deg. Cent. At this temperature the disc will withstand a higher pressure, say, 45 lb per square inch, before bursting. The design pressure of the vessel is then 45 lb per square inch.

The same code states that the total capacity of the safety device and its associated piping must be sufficient to discharge the maximum quantity of fluid that may be generated in or supplied to the vessel, without permitting rise in pressure in the vessel of more than 10 per cent above the permissible working pressure. Calculation of the minimum bursting disc area is therefore a simple matter, and the branch on the vessel which accommodates the disc can be sized accordingly.

Where possible the bursting disc should be mounted close to the vessel. Sometimes it is necessary to mount it on a stand pipe to keep the disc at a reasonably low temperature or to prevent it being splashed by liquids in the vessel.

The design problem is far more difficult when a vessel has to withstand internal explosions. The maximum pressure developed in such a vessel protected by a directly mounted bursting disc is a function of :

(1) The physical dimensions of the vessel.

(2) The ratio of bursting disc area to vessel volume.

(3) The rate of combustion of the vessel contents.

(4) The characteristics of the bursting disc under explosion conditions.

In vessels of equal volume the time for an explosion wave to travel from one end to the other is a function of the vessel depth or length. If the seat of initiation is at the point most remote from the bursting disc, then the maximum pressure developed depends to some extent upon the linear dimensions of the vessel. Pipelines, for example, are notoriously difficult to protect from the results of explosions.

Unfortunately, very little data has been published on the relationship between vessel dimensions and maximum explosion pressures.

It can be stated that a long thin vessel should be avoided, and that the vessel should be designed with the rupture disc as close as possible to the seat of initiation to minimise the time factor.

The ratio between the bursting disc area and the vented volume has a bearing on the maximum pressure developed. Cousins and Cotton[3] have published some useful data on vent ratios for open tanks filled with propane/air and hydrogen/air mixtures which were sparked. A figure of 5 square feet per 100 cubic feet vented volume is a fair allowance for a medium rate burning material, with 2 and 10 the outside figures for mild and violent explosions respectively.

Bursting Disc Characteristics

In general, the pressure at which a bursting disc fails may be expected to increase with increase in the speed of pressure development. Cousins and Cotton in their paper quote some figures for aluminium, brass, copper and Monel discs which indicate that this increase may not be appreciable.

Summing up, the designer of a vessel subject to explosions cannot expect much assistance from the literature in assessing the maximum pressure which the vessel must stand. The rupture disc bursting pressure is fixed by normal operating conditions. The vent ratio must be fixed somewhere between 2 and 10 square feet per 100 cubic feet, depending upon the explosiveness of the reactants, and the number of bursting discs to give this ratio must be assessed so that no disc is too far away from a possible seat of initiation. The design pressure of the vessel must be assessed from Cousins and Cotton's data or from previous experience. Creech[4] has also published a little data, but it is doubtful whether his pressure-recording apparatus was sufficiently sensitive. There is a need for much more data of this type, and equipment users could help by installing high-speed pressure recorders on such vessels.

Typical Applications

[Of the twelve bursting disc applications selected and described as typical by the author we reproduce six.]

(1).

Type of reaction ...	Organic chlorination
Vessel	300 gallon Inconel
Temperature ...	90 deg. Cent.
Pressure	Atmospheric
Bursting disc ...	Silver 0·003in thick ; effective diameter 6in
Bursting pressure...	25 lb/sq in (atmospheric temperature)

This reactor is provided with a liquid seal which blows at a few inches water gauge. The bursting disc is provided as an additional safeguard against an unforeseen emergency, and has not burst during three years' operation. The disc bursting pressure is the hydraulic test pressure of the vessel.

(2).

Type of reaction ...	Friedel and Crafts organic alkylation
Vessel	400 gallon glass-lined cast iron
Temperature ...	140 deg. Cent.
Pressure	Vacuum
Bursting disc ...	Rubber-covered lead ; lead 0·035in thick ; rubber 0·056in thick ; effective diameter 8in
Bursting pressure...	25 lb/sq in (atmospheric temperature)

The bursting disc is supported by a flat, perforated, Monel plate to avoid sagging under vacuum. Both rubber and lead are attacked by the reactants, and the disc occasionally fails prematurely.

(3).

Type of reaction ...	Distillation of high boiling organic liquid
Vessel	700 gallon mild steel still
Temperature ...	400 deg. Cent.
Pressure	50mm Hg absolute
Bursting disc ...	Aluminium 0·006in thick, protected by lead sheet 0·035in thick ; effective diameter 8in
Bursting pressure...	25 lb/sq in (atmospheric temperature)

The lead disc, which is scored before use to weaken it, protects the aluminium from corrosion. Both lead and aluminium, used singly, proved unreliable. The compound bursting disc is supported by a flat, perforated mild steel plate, and is mounted in a long branch on the vapour offtake between still and column to keep the disc temperature well below the vapour temperature.

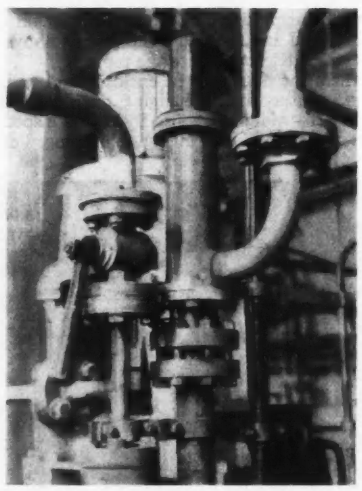

Fig. 3—Relief Valve and Bursting Disc in Series

(4).

Type of reaction ...	Organic condensation
Vessel	1600 gallon autoclave ; mild steel
Temperature ...	240 deg. Cent.
Pressure	850 lb/sq in
Bursting disc ...	Monel 0·015in thick ; effective diameter 2½in
Bursting pressure...	995 lb/sq in at 72 deg. Fah.

The autoclave is fitted with a predished bursting disc and relief valve in series (Fig. 3). The relief valve is set to blow at 950 lb per square inch. This arrangement, which has been used for many years, has given excellent service, and there have been no premature failures. On the one occasion when an excessive pressure developed, both disc and relief valve functioned as scheduled. The bursting disc is mounted on a standpipe above the autoclave so that its temperature is reasonably low, and is changed as a routine measure every three months.

With this type of installation, gas leakage through or around the disc caused by corrosion or faulty installation could cause a pressure build-up above the disc which would increase its bursting pressure. For this reason, it is advisable to provide an open branch between the disc and the relief valve.

(5).

Type of reaction ...	Gas cooling
Vessel	5000 cu ft vertical cylindrical tank, air cooled
Temperature... ...	90 deg. Cent.
Pressure	50in water gauge
Bursting disc ...	Compound, 2 discs of aluminium each 0·006in thick with a disc of compressed asbestos $\frac{1}{32}$in thick between ; effective diameter 22in
Bursting pressure...	75in water gauge (atmospheric temperature)

The use of asbestos gasket material is unusual and may to some extent be traditional, but it appears to give better results than aluminium alone. The discs protect the equipment adequately and seldom fail prematurely. They have been used for about four years.

(6).

Type of reaction ...	Catalytic oxidation (vapour phase)
Vessel	Fixed bed catalytic convertor
Temperature ...	150 deg. Cent.
Pressure	12 lb/sq in
Bursting discs ...	Compound ; two discs of aluminium each 0·004in thick with a disc of compressed asbestos $\frac{1}{32}$in thick between ; effective diameter 12in
Bursting pressure...	20 lb/sq in (steam test)

The catalytic convertor is subject to explosions, which are not uncommon. This type of bursting disc has been used successfully for many years. Premature failures occur occasionally because of the variable quality of the aluminium.

Conclusions

It is usually simple to ensure that a bursting disc will never remain whole when subjected to a pressure above a certain maximum, and as a device for protecting vessels against excessive pressure and, to some extent, explosions, the bursting disc has proved satisfactory. The author has never had any experience of a disc not operating when it should.

The use of bursting discs in the chemical industry will undoubtedly increase now that supplies of discs with a guaranteed bursting range are available. American users have in the past had a great advantage over British users in this respect, and it is encouraging that a start has been made on the centralised manufacture of high-grade bursting discs in this country.

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[4] Creech, M. D., "Combustion Explosions in Pressure Vessels Protected with Rupture Discs," *Trans. A.S.M.E.*, October, 1941.

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FAKRA-Handbuch. Second edition. Edited by Fachnormenausschuss der Kraftfahrzeugindustrie (FAKRA) (the Standardisation Organisation of the German Automobile Industry.) VDA-Wirtschaftsgemeinschaft, Frankfurt a.M. Price Dmk. 16.—This handbook is a pocket book containing about 400 standard specifications of automobile components and those accessories which are generally purchased by the motor industry from common sources. It does not contain those standard specifications of tools, metals, ball and roller bearings which are to be found in the DIN (Deutsche Industrie Normen) and ISO (International Organisation for Standardisation) reference books. The book, the first edition of which was first published in 1931, has been completely revised and brought up to date ; a great number of specifications has been added, while others which have become obsolete have been removed from the standards list. In its present form it gives a very complete survey of the state of standardisation in the German automobile industry and can be recommended to designers as well as to production engineers who are interested in international standardisation.

VDA-Autotypenbuch, 1952. Twenty-ninth edition. VDA-Wirtschaftsgemeinschaft Frankfurt a.M. Price Dmk. 15.—This second post-war edition of a well-known reference book contains in Vol. 1 the essential technical data of all German motor-cars, public service and commercial vehicles, special-purpose vehicles, trailers, and of proprietary vehicle engines. Vol. 2 deals extensively with automobile equipment and accessories. The book, which is well illustrated, is a useful ready reference to the specifications of German automotive products.

Welding in Marine Engineering

By H. N. PEMBERTON, M.I.Mech.E.*

No. I

The twenty-fifth Thomas Lowe Gray Lecture, which was read before the Institution of Mechanical Engineers on January 9th, and of which we publish an abstract, surveys and comments on the use of welding for the construction and repair of marine machinery. This history of welding is traced, various applications are grouped in a section entitled "New Construction," and several examples of weld repairs are described.

WELDING has been practised ever since men found that two pieces of metal, after being heated to a suitable degree of plasticity, could be hammered together to form a joint. The village blacksmith was the forerunner of the welder, and his craft formed the basis of all techniques since evolved for the same purpose.

Towards the end of the nineteenth century water-gas forge welding was introduced, whilst in iron-foundries the process was developed whereby a broken, or otherwise deficient, casting could be repaired by pouring molten iron into a mould built around the parts to be welded.

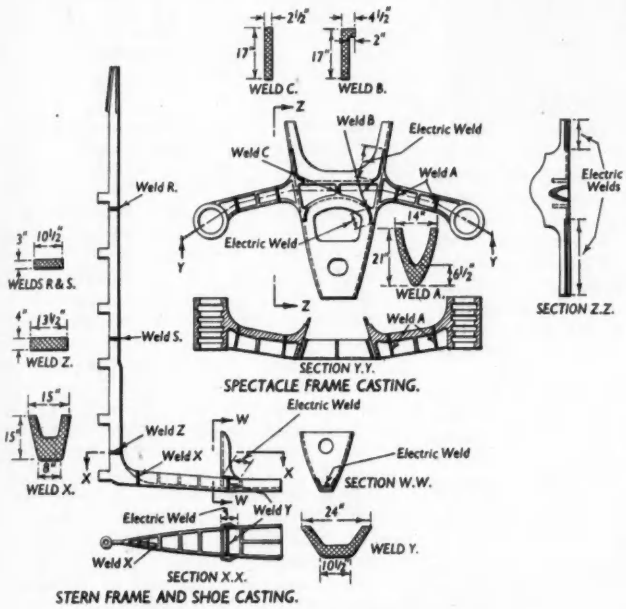


Fig. 1—"La Paz" Fabricated Spectacle Piece

The first applications of the electric arc as a source of heat for welding were made in Russia, by Benardos in about the year 1887. Little progress was made, mainly because of the development of oxy-acetylene welding, following the discovery of acetylene by Spray, in the United States in 1892.

In the Benardos process, the arc was struck between a carbon electrode and the parts to be welded, which were heated to a plastic condition and hammered together.

The electric-arc fusion welding process of to-day is that developed by another Russian, Slavianoff. The carbon electrode used by Benardos is replaced by a metal electrode which, when the arc is struck, melts into the arc stream and is deposited in the molten pool formed in the surface of the base metal.

In the early days of the process the arc was not continuous and the electrode was an iron, or low-carbon steel bar about $\frac{3}{16}$in in diameter.

It is of interest to note that the first authoritative suggestion that repairs to boilers, such as fitting patch plates in combustion chambers and furnaces and the welding of cracks in furnaces, could be effected by electric and oxy-acetylene welding appears to have been made by Mr. H. Ruck-Keene (later chief engineer surveyor to Lloyd's Register of Shipping) in a paper read to the Institute of Marine Engineers in 1907.

Electric-resistance welding also appeared at the beginning of the present century, and slow, but steady, progress was made by all three processes until the 1914–18 war, which provided an incentive for rapid improvements in welding equipment.

In marine engineering the longitudinal seams in the iron shell plates of boilers were forge welded by certain manufacturers in 1870. About this time, Lloyd's Register of Shipping and the Board of Trade (now the Ministry of Transport) approved the process of hammer welding the seams of marine boilers, and an iron boiler constructed in 1877 with shell plates $1\frac{3}{16}$in thick, having welded longitudinal seams, remained in service, at the original working pressure of 80 lb per square inch, until January, 1940, when the ship was sunk by enemy action. Some failures of hammer-welded seams in iron boilers occurred, and the practice ceased, so far as shell seams were concerned.

Until recent years, forge welding was the only acceptable process for the manufacture of welded steam pipes. Resistance welding and fusion welding are, however, now permitted subject to certain limitations in operating conditions. Water-gas forge welding has also been used for many years in the construction of plain and corrugated furnace tubes.

About 1900, Dr. Hans Goldschmidt introduced his process of "Alumino-Thermic" welding for repairing large forgings and castings. The process was named "Thermit," and the ingredients of the "Thermit" mixture, finely divided aluminium and iron oxide, when placed in a crucible and ignited, started an exothermic reaction, separating into aluminium oxide and an iron of pure quality at a temperature of about 5400 deg. Fah. The molten iron was then poured into a refractory mould built around the two parts to be welded together. This was, in effect, a casting process, in which the heat generated melted the surfaces to be joined together and the gap between them was filled with added metal.

In 1906, Lloyd's Register of Shipping was asked to approve the "Alumino-Thermic" welding process, and special tests were carried out on a forged iron stern frame obtained from S.S. "Peruviana." The results were unsatisfactory and the process was not approved. In 1924, as the result of further tests, it was decided to accept the process for making temporary repairs to parts of the hull structure that were not subject to torsional stress. In the United States of America, the process is in common use not only for repair work, but also for new construction. Stern frames and "spectacle pieces" are frequently constructed from comparatively small castings welded together. The weld metal formed

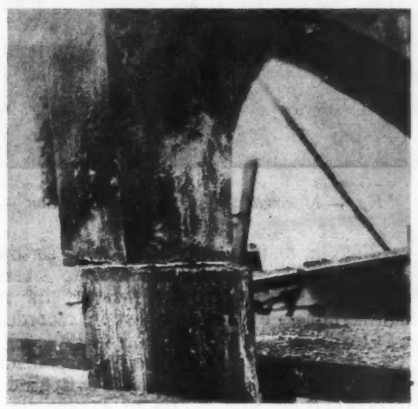


Fig. 2—Broken Parts

in this process is liable to be spongy, and sensitive to fatigue and corrosion fatigue conditions. For this reason, Lloyd's Register of Shipping restricts its use to those parts of a ship's structure which are not subject to dynamic loadings.

An interesting example was that of the "La Paz," which was torpedoed and lost the entire underwater part of the stern. She was repaired in the United States, where both the stern frame and spectacle piece were fabricated from cast steel sections welded together by the "Thermit" process (Fig. 1).

Figs. 2 and 3 illustrate the repair of a fractured rudder post, the two broken parts of which had sprung out of line. The mould was built round the parts and the molten "Thermit" mixture poured into the mould and the finished weld as shown.

Fig. 3—Finished Weld

In 1890 it was proposed to repair marine engine crankshaft defects by electric arc welding, but the results were discouraging. The first successful application of electric-arc

* Assistant chief engineer surveyor, Lloyd's Register of Shipping.

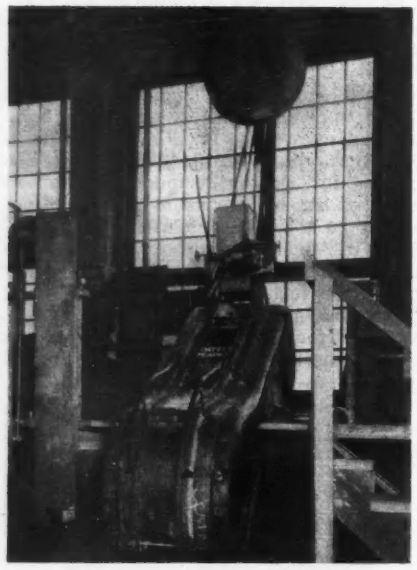


Fig. 4—Manipulator for Welding Combustion Chambers

welding in marine engineering was in the welding of flanges and branches to steam and other pipes, and the first repairs to marine boilers by this process were recorded by Lloyd's Register of Shipping in 1906.

In 1917 and 1918, in addition to tests made by the British Admiralty, Lloyd's Register, in conjunction with a firm of shipbuilders, carried out tests to determine the physical properties of electrically welded joints, the results of which were summarised thus.

The modulus of elasticity of deposited weld metal did not differ greatly from that of steel ; the ultimate strength of butt-welded joints approximated closely to that of the unwelded parent metal ; round bars containing a butt-weld had a fatigue limit (Wöhler test) about 60 per cent of that of the solid bar ; butt-welded joints had only a limited capacity to resist bending, but had considerable resistance to impact.

These conclusions led to the acceptance by Lloyd's Register of Shipping of welding for ship construction, and " Tentative Regulations for the Application of Electric Arc Welding to Ships " were issued in 1918. These were the first rules of this kind to be formulated by any ship classification society.

In 1919 plans for the first ship to be electrically welded were approved by Lloyd's Register of Shipping, but it was not until ten years later that marked progress took place, due largely to the improvements in the quality of electrodes.

In 1934, the rules of Lloyd's Register were revised, and fusion welding by the electric arc and oxy-acetylene processes was no longer prohibited for parts of boilers, air receivers,

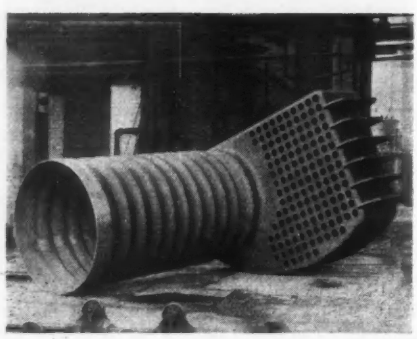


Fig. 5—All-Welded Furnace and Combustion Chamber

&c., which were in tension, and the Register issued tentative rules governing the entire construction of pressure vessels by welding, which were the first regulations of this nature to be published by any authority in Europe.

The experience gained in this work led, in 1938, to the rules being extended to cover marine installations.

The scantlings of fusion welded pressure vessels, when first introduced, for the thickness of Class 1 shells or drums were based on a joint efficiency of approximately 85 per cent, equal to that obtainable in a treble-riveted joint with double butt straps and five rivets per pitch, but now a strong case can be made out for an increased efficiency factor.

New Construction

The increased confidence in welding during recent years has led engineers to consider welding " Scotch " multi-tubular marine boilers, which, for certain ships and machinery installations, are the most suitable steam generators.

" All-welded " multi-tubular boilers were made for the 4700-ton standard cargo ships built in Canada during the 1939–45 war. In these boilers all seams are welded, but the stays were screwed and fitted with nuts in the conventional way.

Mr. A. E. House, of Vancouver, designed a manipulator to weld combustion chambers by the automatic process. The device shown in Fig. 4, consisted of a light, fabricated guide track, loosely fitted, and conforming to the profile of the combustion chamber wrapper plate. The track was held firmly in line with the seams to be welded by means of set screws. The combustion chambers were assembled, tack welded by hand, then mounted in the manipulator between two face-plates and rotated about the centre of gravity.

The welding head remained stationary relative to the axis of the rotation of the combustion chamber, but, being supported on the track, it moved up and down in the vertical plane as it followed the contour of the wrapper plate. The welding head drive was obtained through a rack-and-pinion device, in which a sprocket wheel in the head engaged with a roller chain fixed round the combustion chamber. Variable-speed motors were necessary for rotating the work and for driving the welding head, since perfect synchronism had to be obtained between the speed of travel of the welding head and the speed of rotation of the combustion chamber.

Much attention has been given to the welding of combustion chambers. By using " corner " welds the flanging of tube and back plates may be eliminated. The avoidance of leakage and edge cracking in seams of combustion chambers is of real advantage.

Corner welds have been adopted for the joints between shell and end plates with satisfactory results in service, but some manufacturers prefer to retain the curved flange which is butt-welded to the shell plate to reduce stress concentration at the corners.

A further advantage of welded over riveted seams in boilers is the elimination of all interstices in which alkaline concentrations may occur and cause caustic cracking between rivet holes. Such a smooth appearance is well illustrated in Fig. 5.

It is the requirement of most authorities that welded joints in tension in the shell plates of boilers must be stress-relieved by heat-treatment, and in consequence of the limitations of stress-relieving furnaces, the longitudinal joints in the shells of large " Scotch " boilers must be riveted. There is need for the development of portable heat-treating appliances, such as an electric inductance heater which can be applied locally to the welded joints of large boilers.

It is common practice to secure combustion chamber and longitudinal stays in " Scotch " boilers by means of welding. The methods used are shown in Fig. 6 and have been based on experiments carried out by Lloyd's Register of Shipping in 1943 to establish the degree of support given to flat plate surfaces by different methods of welded stay attachments. One advantage claimed is that the stay bars need not be machined, being usually round enough " as-rolled " to provide a reasonable fit in the stay holes. The rolled surface resists

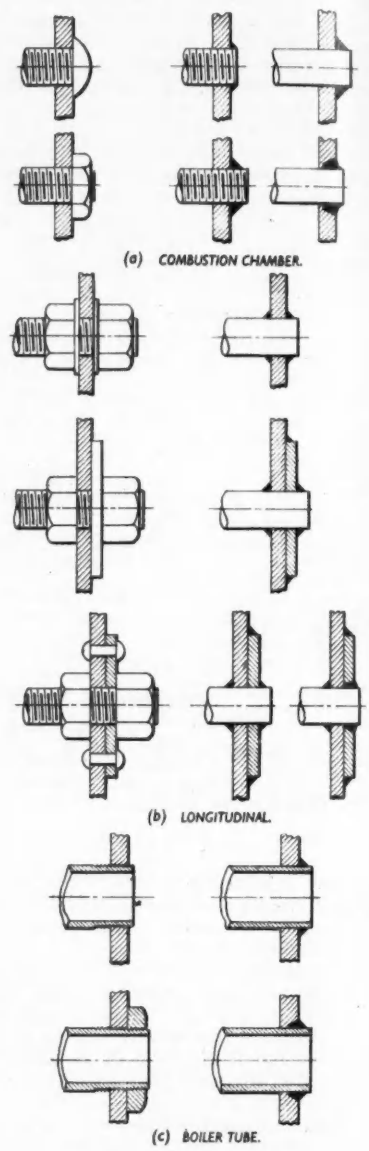


Fig. 6—Stay Connections

corrosion better than a machined surface, but note that broken mill scale will accelerate corrosion.

A peculiar defect occurring in welded stay bars is that no defect is visible before welding, but leaks develop under hydraulic test from small radial cracks. The cracks emanate from reeds in the billets from which the bars are rolled, and in screwed stays these longitudinal, surface fissures are machined out. Stays for welding are not usually machined and the welding tends to open up the fissures and leakage occurs. These defects can be avoided if the billets are " deseamed " by flame gouging. A suitable test is to crop a piece

from the end of the bar, of length equal to its diameter and, after heating to redness, compress it axially to half its length. No signs of fracture or " fissuring " should appear.

It is not usual to weld the smoke tubes into the front and back tube plates of " Scotch " boilers. A light sealing weld round each tube end should be effected on the water side of the tube plates, which would prevent leakage, but it is wiser to rely on the orthodox methods of expanding the tubes, rather than on a weld which might obscure serious wastage between tube and plate. This might be serious in the case of stay tubes where the load might be transferred to the weld as the screw threads corroded away, however. Stay tubes secured only by welding have been accepted. Vertical boilers have benefited from the application of welding and, being smaller than the " Scotch " boiler, the outer shell presents little difficulty in construction, welding or stress relieving. It is in the construction of the inner shells that greatest advantage is obtained from welding. It should be noted that by welding the circumferential joints of the inner shell considerable saving of riveted joints may be effected.

The higher steam temperatures and pressures necessitate the use of water-tube boilers and their drums and headers must be either solid forged or fusion welded. The former having no joints, except girth seams, when the drums are made up from a number of solid-forged cylinders. The size of the solid-forged drum is limited by the maximum size of ingot available. Thus this process is generally applicable to the smaller drums only; moreover, manufacture is more costly than for welding, and this disadvantage increases with the size of the drum.

The standpipes and pads to which the boiler mountings will be attached are usually welded on and they may be " set in " or " set on." Typical methods are shown in Fig. 7. For very thick drums and standpipes the " set on " welded attachment offers less restraint during welding than the " set in " type and is less prone to root cracking in the weld.

The largest boiler drum yet constructed by welding in the United Kingdom is shown in Fig. 8. The drum is 43ft long and 60in in diameter. The shell plate, made of steel 34–40 tons per square inch, is 5 $\frac{1}{16}$ in thick, and the finished weight of the drum is 80 tons. It illustrates the extent to which welding can be applied to-day, as regards both the thickness and tensile strength of welded steel plates. It is considered that greater use could

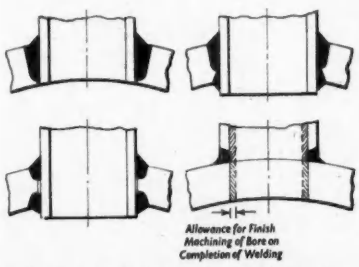


Fig. 7—Typical Methods of Attaching Standpipes

be made of this higher tensile steel for the construction of welded drums for marine water-tube boilers, for which higher working stresses could be allowed than in the more commonly used steel 28–32 tons per square inch.

Welded drums for marine boilers were first accepted by Lloyd's Register of Shipping in 1938, following extensive experience gained in land service. The first passenger ship having welded boiler drums went into service about a year later, but by that time several oil tankers, built in the United States and classed with Lloyd's Register, were in service, with water-tube boilers having welded drums and working at steam pressures of 400–625 lb per square inch and superheat temperatures of 750–835 deg. Fah.

Tubes made by means of electric-resistance welding are accepted by Lloyd's Register of Shipping for use in boilers and for pressure piping. Electric-resistance welded tubes are made from cold, flat, steel strip fed continuously to the mill, where a train of rolls

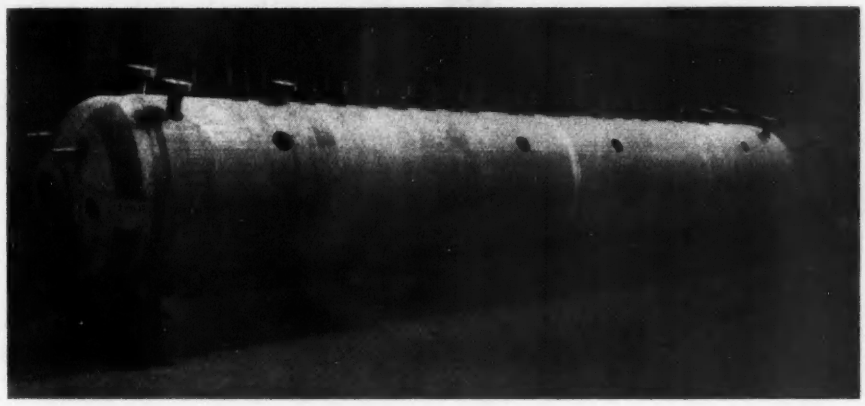


Fig. 8—Steam Drum for Water-Tube Boiler

forms the strip into tubular shape with a longitudinal gap. The tube with the gap uppermost then passes under the electrodes, where the passage of low-voltage current across the gap generates sufficient heat to melt the abutting edges of the tube, and a pair of horizontal squeeze rolls close the gap and make the weld. In this operation the rolls squeeze out the excess metal in the form of a fin, on the inside and outside of the welded tube, the fins being subsequently removed by cutters.

The most general application of welding in marine pipework is in the attachment of flanges. Fig. 9 shows the various acceptable methods of securing flanges. The butt-welded flange joint is the best, since it does not involve any change in direction of stress lines at the weld. It also has the advantages of being simple to weld, and that the welding can be carried out free of restraint, with consequent minimum distortion.

A common defect in butt-welded pipe joints is insufficient root penetration and must be avoided in high-pressure steam pipe joints. Two methods are normally used for overcoming this difficulty in welded pipes which are too small to " back chip " and be welded from the inside. One is to use a " backing ring " inside the pipe, to localise the penetration of the welding arc, and prevent the burning of the bevelled edges of the pipe at the root of the welding groove. The second method is to employ oxy-acetylene welding for the initial root run, and is the better method for mild steel piping which cannot be welded from the inside of the pipe. The remainder of the welding groove is filled by arc welding.

For certain alloy steels, oxy-acetylene welding is unsuitable, and backing rings do not provide a satisfactory solution because of the tendency for basal cracking at the root. For these, the practice is to preheat the pipe ends to a suitable temperature and arc weld the joint throughout, and radiographic examination of the root run should be carried out before completing the weld.

The " slip-on " type of welded flange has the disadvantage of a directional change in stress lines concentrated in the fillet weld at the back of the flange, and there is a tendency for distortion of the flange face. Erosion of the inside fillet weld, which is in contact with the flowing contents of the pipe line, is a serious possibility.

Steam pipe welds should always be stress relieved by thermal treatment. This is of special importance with carbon-molybdenum and chromium-molybdenum alloy steel pipes. It is not yet the practice in the United Kingdom to weld steam pipe joints *in situ* on board ship, but the need to reduce the number of flange joints to a minimum in high-pressure steam lines will no doubt lead to this, then preheating and stress relieving will best be carried out by means of induction or resistance heating coils. In addition to the heat-treatment, the welds

Fig. 9—Typical Methods of Securing Pipe Flanges

should be examined by means of radiography, for which the use of gamma rays, using a cobalt-60 radiation source, has been found suitable in power-house work. Ideally, the whole of a superheated steam line from boiler to turbine should be welded.

(*To be continued*)

Woolwich Arsenal Committee of Inquiry

AT the end of last week it was announced that the Minister of Supply, Mr. Duncan Sandys, had appointed an inter-departmental committee to review the various activities at Woolwich Arsenal, and to formulate proposals for the use of such parts of the area as are no longer required for their present purposes. The committee is directed to consult with outside parties interested in the problem. Sir Donald Perrott, of the Ministry of Supply, is to act as chairman of the committee, the membership of which includes representatives of the Admiralty, War Office, Ministry of Labour and Ministry of Housing and Local Government. The decision to set up this committee follows upon the conclusions expressed in a report on the Royal Ordnance Factories, which was prepared by the House of Commons Select Committee on Estimates, and published last November. That report, it will be recalled, recorded the committee's view that Woolwich Arsenal was regarded by the Ministry of Supply as " something of a white elephant." The committee therefore recommended that the question of the use of the Arsenal and its fuller integration with the whole organisation of the Royal Ordnance Factories should be given immediate consideration.

Gas Turbines in 1952

No. II—(*Concluded from page 89, January 16th*)

Fuel Research Station

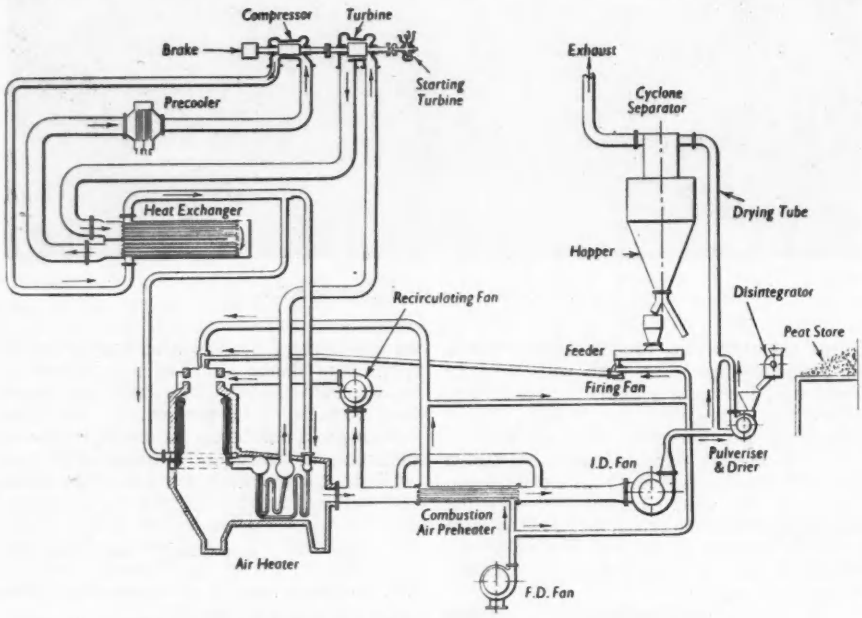
FROM some notes contributed by the Fuel Research Station, Blackwall Lane, Greenwich, S.E.10, we learn that the centre of the field of research on the use of solid fuels in gas turbines is tending to move from the problems of combustion, to those of ash separation in the case of the open cycle and to heat exchanger problems associated with the closed and exhaust heat cycles. The progress made can be assessed from the fact that successful tests have been made in Britain on three gas turbines fired with solid fuel. One of these units has undergone extensive testing, but the duration of the tests of the two remaining units was too short for final conclusions to be drawn. The most recent advance in the open cycle field was the initial test made by Ruston and Hornsby, Ltd., on its 750kW unit fired with pulverised peat.* One interesting feature of this plant is the feeding of the fuel from a pressurised fluid bed, which permits a sensitivity of control comparable with that of oil firing. In the final plant, drying of the peat is to be carried out partly by means of a dewatering press and partly by means of the heat in the exhaust gas, and the moisture content will thus be reduced from 90 per cent to a value suitable for combustion. The plant is now being prepared for prolonged tests.

Further tests on its experimental, coal-fired, open-cycle gas turbine have been made by C. A. Parsons and Co., Ltd., and a total test time of thirty hours on load has been achieved. The ash separators which were provided to remove the pulverised coal fly ash collected 90 per cent of the particles larger than 20 microns and 70 per cent larger than 10 microns, and with this degree of clearing no damage to the turbine blades was observed during the tests.

In America, the Locomotive Development Committee has constructed a 4000 h.p. open-cycle gas turbine fired with pulverised coal, the unit being suitable for installation in a locomotive. The combustion section consists of twin, metallic, film-cooled combustion chambers followed by a battery of "Dunlab" tubes for ash separation. A 750-hour test on the plant has been completed and information on the possible erosion of the turbine blades is awaited with interest.

The possibilities of a closed-cycle gas turbine using pulverised peat as fuel is being investigated by John Brown and Co., Ltd. In the present installation the output from the turbine is very small for the size of plant, mainly because the compressor is not operating at its designed pressure ratio, but a redesigned plant should be capable of an output of 2000 h.p. in the same space as that occupied by the existing 500 h.p. plant.

Investigations are in progress, the notes continue, at the McGill University, Canada, making use of the exhaust heat cycle whereby the efficiency is made to approach that of either the closed or open cycle by means of a special arrangement of "hot" and "cold" heat exchangers. The turbine exhaust is split into two streams, one of which passes through the hot heat exchanger after being heated in the combustion chamber and then rejoins the other stream before passing through the cold heat exchanger. The hot heat exchanger operates initially at a temperature of about 1100 deg. Cent., thus presenting new problems in design. References to some of these installations appear below.



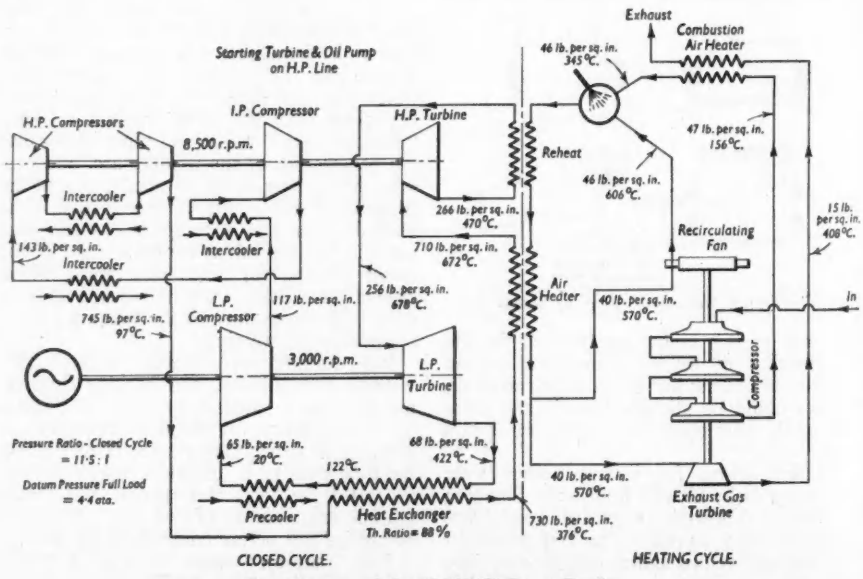
Diagrammatic Arrangement of Gas Turbine and Peat Combustion Plant

John Brown and Co., Ltd.

In this review last year we were able to describe and illustrate an experimental peat-fired, closed-cycle gas turbine plant, a project undertaken by John Brown and Co., Ltd., on behalf of the North of Scotland Hydro-Electric Board, the plant having then completed thirty hours' running. Since that time the company has completed a 1000 hours' running programme and it has been shown that peat up to 50 per cent wet can be used satisfactorily as a fuel for closed-cycle combustion plant. Large commercial plants are now under consideration. The peat preparation plant incorporates an "Attritor" coal pulveriser, drying tubes and a Howden centrifugal separator. Partial drying is obtained on the pulveriser by passing a proportion of the exhaust gases through the unit in which flow the peat is entrained. It then passes upwards with the remainder of the waste gases through the drying tubes to cyclone separators, thence falling through a hopper to a feeder belt from where it is fed by a firing fan to the burners. The complete flow diagram is reproduced herewith.

At the Carolina Port generating station, Dundee, a 12,500kW oil-fired, closed-cycle gas turbine is to be operated and the erection of this plant is now nearing completion. A diagrammatic arrangement of the Escher Wyss cycle on which this plant will operate is reproduced below. It will be noted that the datum pressure is 4·4 atmospheres, and the pressure ratio 11·5 : 1, giving a pressure at the h.p. turbine of 710 lb per square inch with a temperature of 672 deg. Cent.

Work proceeded during last year on the 700kW closed-cycle gas turbine which is to be installed during 1953 in the Coventry gasworks of the West Midlands Gas Board. This plant is to operate on the waste gases from the Glover West vertical retorts, and since the heat rejected by the gas turbine cycle is largely absorbed in the



Flow Diagram of the 12,500kW Set at Dundee

* Referred to in Jan. 16th issue, page 86.

water used in the various processes of the gasworks, the overall heat utilisation of this plant will be over 70 per cent.

The cycle is contained on a single shaft and operates with a datum pressure of 32·2 lb per square inch and a pressure ratio of 4·4 : 1 at 9500 r.p.m. Air leaving the first compressor (axial) is cooled and passes through three centrifugal stages before entering a heat exchanger. In the air heater the working fluid temperature is raised from 328 deg. to 600 deg. Cent. The turbine exhausts at 34·3 lb per square inch and 360 deg. Cent., the air then passing via a heat exchanger of 86 per cent thermal efficiency to a precooler.

The tubular air heater is intended to utilise heat from some 60,000 lb of waste gases per hour at 800 deg. Cent. which will be available from the retorts of a new carbonising plant. The entire flow can be diverted to a boiler operating at 120 lb per square inch.

Further data on this plant were given in a paper entitled "Application of the Gas Turbine for Recovery of Waste Heat," by Captain W. Gregson, R.N.R., before the Institution of Gas Engineers, London, during November last.

Under contract from the Ministry of Fuel and Power, the company has continued its development work on a liquid slagging coal combustion chamber suitable for use with gas turbine installations, and the peat-fired plant is now being converted for coal firing.

There is also under construction at Clydebank a 1000kW coal-fired, closed-cycle gas turbine to be installed in a works where the waste heat from the plant will be used for space heating. The overall heat utilisation will be about 45 per cent.

C. A. Parsons and Co., Ltd.

As a result of the successful tests undertaken last year by C. A. Parsons and Co., Ltd., at Heaton Works, Newcastle upon Tyne, 6, on the burning of pulverised coal in its 500 h.p. experimental gas turbine plant, the Ministry of Fuel and Power, after consultations with the Railway Executive, has ordered an open-cycle, external-combustion, coal-burning gas turbine locomotive. The running gear will be made by the North British Locomotive Company, Ltd. The locomotive, arranged with mechanical transmission, will be powered by a gas turbine of 1800 h.p., giving a maximum rail horsepower of 1600. The design overall efficiency of the installation is believed to be 19 per cent full load, and the maximum temperature in the cycle about 700 deg. Cent. at the compressor turbine. Air leaving the combustion chamber passes through the air heater, and then through a waste heat boiler to atmosphere.

Work is proceeding on the erection of the 15,000kW gas turbine-alternator at Dunston power station, and on the 10,000kW set for the National Gas Turbine Establishment at Farnborough. Smaller machines under construction are a standard 2500kW plant and a 2000kW plant for the Municipality of Singapore.

The Dunston set employs two low-pressure shafts with compressors in series and an intercooler, feeding via another intercooler the high-pressure shaft on which is mounted the alternator. Air from the h.p. compressor divides, each half passing through three of six heat exchangers arranged in parallel, to a combustion chamber. The gases then pass through the h.p. turbine and are again divided, both flows being reheated before expansion in the low-pressure turbines. The separate exhaust from each l.p. turbine then passes likewise through three of the six heat exchangers and is exhausted.

Shipbuilding and Marine Engineering in 1952

No. IV—(*Concluded from page* 106, *January* 16*th*)

Oil Tankers

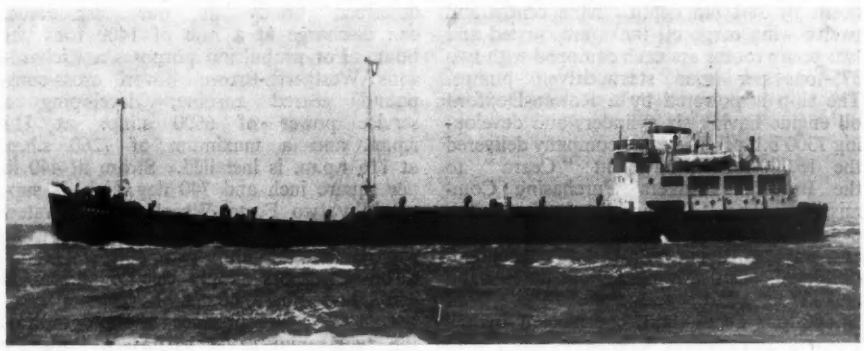
OIL tankers have continued to occupy a majority of the shipbuilding berths, and more than half the ships completed during the year belonged to this class. The largest tankers delivered were the "World Concord," illustrated on Plate 3 of our January 9th issue, and "World Unity," described in The Engineer, June 20, 1952. Both ships were built by Vickers-Armstrongs, Ltd., for the North American Shipping and Trading Company (London), Ltd., and carry a deadweight of 31,745 tons on the following dimensions : length between perpendiculars 625ft, by 86ft breadth moulded, by 45ft 9in depth and a summer draught of 33ft 10½in. There are thirty cargo oil tanks and one pump room equipped with three 850 tons per hour turbo-driven pumps. A single set of steam turbines developing a maximum of 13,750 s.h.p. at 103 r.p.m. drives the ship through double-reduction articulated gearing at a service speed of 15 knots. Steam is supplied by two Foster-Wheeler "D" watertube boilers under Howden's forced draught, at 450 lb per square inch and 750 deg. Fah. and two 500kW Allen turbine-driven alternators supply the electrical power with a 100kW Davey-Paxman diesel-driven alternator as an alternative means of supply.

The tankers joining the fleet of the British Tanker Company, Ltd., included some of the 28,500 ton deadweight class, such as the "British Talent" from R. and W. Hawthorn, Leslie and Co., Ltd., and "British Skill," from Harland and Wolff, Ltd. Both ships have a length between perpendiculars of 610ft by 81ft beam by 44ft 6in depth and a service speed of 15 knots and the cargo oil is carried in thirty tanks served by one pump room fitted with three pumps. The propelling machinery consists of a set of compound double-reduction geared turbines developing a maximum of 13,750 s.h.p. and taking superheated steam from two Foster-Wheeler "D" boilers in the first-named ship and from two Babcock and Wilcox integral furnace boilers in the second ship.

The "Velletia," the last of the programme of four 28,000-ton deadweight oil tankers ordered by the Anglo-Saxon Petroleum Company, Ltd., was completed by Swan, Hunter and Wigham Richardson, Ltd., and is the sister ship to the "Velutina," which was handed over in 1950. The ship has a length between perpendiculars of 610ft by 80ft 6in beam by a depth of 45ft, and is driven at a service speed of 15 knots by a set of turbines built by the Wallsend Slipway and Engineering Company, Ltd. Developing a maximum of 13,000 s.h.p. at 106 r.p.m. the double-reduction geared triple-expansion turbines take steam at 500 lb per square inch and 750 deg. Fah. from three Babcock and Wilcox single-pass boilers.

Several ships went into service with the Hunting group of companies, including the "Tynefield," built by R. and W. Hawthorn, Leslie and Co., Ltd., which carries a deadweight of 18,500 tons on a length overall of 557ft by 70ft beam by a depth of 39ft 6in, and is powered by a six-cylinder Hawthorn-Doxford oil engine developing 7600 b.h.p. at 114 r.p.m. Two sister ships, the "Wheatfield" and "Gretafield," were delivered from the Haverton Hill yard of the Furness Shipbuilding Company, Ltd. They have a length between perpendiculars of 496ft, a breadth moulded of 67ft 6in, a depth moulded of 36ft 5in and carry a deadweight of 16,500 tons on a Lloyd's summer draught of 29ft 1½in. Each has twenty-seven cargo oil tanks and a single pump room equipped with two 400 tons per hour duplex steam pumps. The designed speed is 14 knots and each ship is propelled by a five-cylinder Doxford oil engine developing 5500 s.h.p. at 112 r.p.m. Smaller in size, the "Duffield" was completed by Smith's Dock Company, Ltd., and has a deadweight capacity of 14,890 tons on 28ft 9½in draught and a service speed of 13 knots. The dimensions are : length overall 506ft, breadth 67ft, depth 36ft 3in. There are twenty-seven cargo oil tanks served by one pump room fitted with two 500-tons per hour pumps. The main propelling machinery consists of a four-cylinder Hawthorn-Doxford of 4450 b.h.p.

The "Corato," illustrated on Plate 3 in our issue of January 9th was built by the Greenock Dockyard Company, Ltd., for the Hadley Shipping Company, Ltd., and has a deadweight of 16,636 tons on a mean draught of 29ft 10in. The main dimensions are : length between perpendiculars 512ft, breadth 69ft, depth 38ft 6in. The ship has a designed trial speed of 13½ knots. Cargo oil is carried in nine centre and sixteen wing tanks divided by two main pump-rooms, each equipped with two 250-tons



Motor Collier "Corbrae"

per hour steam pumps. A five-cylinder Scott-Doxford oil engine developing 5500 b.h.p. in service is the main propulsion unit and three 75kW Allen generators, two steam-driven and one diesel-driven, supply the necessary electrical power.

The "Caltex Liverpool," owned by Overseas Tankship (U.K.), Ltd., and built and engined by R. and W. Hawthorn, Leslie and Co., Ltd., was also shown on Plate 3, January 9th. This ship carries a dead-weight of 17,250 tons on a length overall of 544ft 4in by 70ft beam by 39ft 9in in depth. There is one pump room equipped with three Drysdale horizontal pumps for loading and discharging the cargo. The main propulsion machinery consists of one set of double-reduction geared compound turbines of 8200 s.h.p. supplied with steam at 450 lb per square inch and 750 deg. Fah. by two Yarrow three-drum boilers and the electrical generating plant consists of two 400kW geared turbo-generators, one working and one standby.

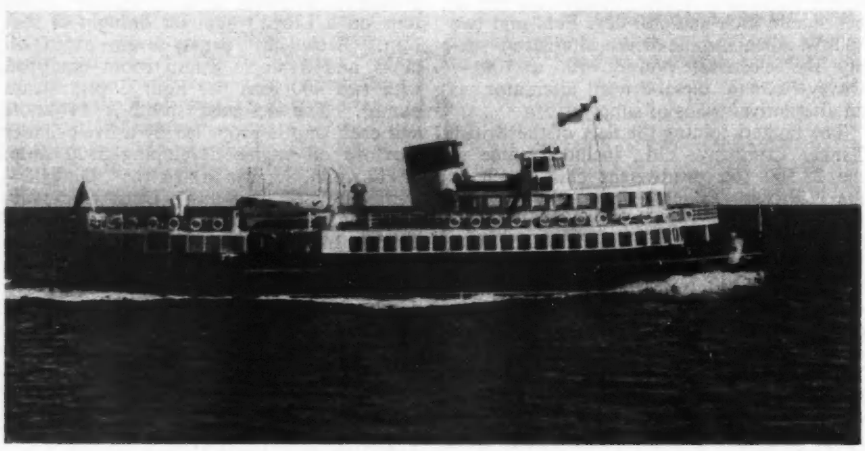
Several oil tankers were built for foreign owners, including the "North King" by the Blythswood Shipbuilding Company, Ltd., for the Compania Petrolera De Transportes, S.A. A deadweight of 18,700 tons is carried at a draught of 30ft 7in on a length between perpendiculars of 530ft by 72ft 9in beam by 38ft 8in depth. Nine centre and twelve wing cargo oil tanks are carried and two pump rooms are each equipped with two 375-tons per hour steam-driven pumps. The ship is powered by a Rowan-Doxford oil engine having six cylinders and developing 7300 b.h.p. The same company delivered the 16,700-tons deadweight "Ceara" to the Brazilian Tankers' Purchasing Commission. The "Dagland," of 15,560-tons deadweight, completed by Swan, Hunter and Wigham Richardson, Ltd., the "Janita," of 18,500-tons deadweight, built by Harland and Wolff, Ltd., and the "Sibella," of 24,600-tons deadweight, constructed by the Furness Shipbuilding Company, Ltd., were among the ships delivered to Norwegian owners.

Special Ships

Towards the end of the year the trials were completed of the self-unloading bauxite ore carrier "Carl Schmedeman," built by Vickers-Armstrongs, Ltd., for Reynolds Jamaica Mines, Ltd., and illustrated in our last issue. The ship, which is almost completely welded, has a length between perpendiculars of 500ft by 66ft breadth moulded by 37ft 3in depth moulded to the main deck and a deadweight of 13,150 tons. The bauxite is carried in four holds, each served by two hatches fitted with MacGregor steel hatch covers, and fed by gravity through gates on to twin hold conveyors, which carry the ore aft to a transverse belt shuttle conveyor discharging to port or starboard through doors in the ship's side. The system, which we described briefly in our last issue, can discharge at a rate of 1400 tons per hour. For propulsion purposes a Richardsons Westgarth-Brown Boveri cross-compound geared turbine, developing a service power of 6600 s.h.p. at 112 r.p.m. and a maximum of 7260 s.h.p. at 116 r.p.m. is installed. Steam at 440 lb per square inch and 740 deg. Fah. is supplied by two Foster-Wheeler "D" water-tube boilers burning oil fuel under Howden's forced draught and two 400kW geared turbo-alternators supply electric current at 450V, three-phase, 60 c/s.

Last week we reproduced a photograph of the twin-screw cable steamship "Stanley Angwin," which was built and engined by Swan, Hunter and Wigham Richardson, Ltd., for Cable and Wireless, Ltd., and is essentially a sister ship of the "Edward Wilshaw," built in 1948. The ship, which will be responsible for a 20,000-mile section of the marine cable system between Colombo and the Pacific Ocean, has a length overall of 315ft by 41ft beam by 25ft 9in depth to upper deck and a load draught of 19ft, corresponding to a deadweight of 2200 tons. Three cable tanks are located forward of the boiler room and have a total coiling capacity of 18,850 cubic feet, equivalent to 400 miles of deep-sea cable. Two independent cable gears manufactured by Johnson and Phillips, Ltd., and taking steam at full boiler pressure, have been fitted. The main propelling machinery consists of two sets of triple-expansion engines developing a total of 1450 i.h.p. at 104 r.p.m. and taking saturated steam at 220 lb per square inch, which is generated in two single-ended multitubular Scotch boilers, burning oil fuel under forced draught.

Pusher Tug "Adama"



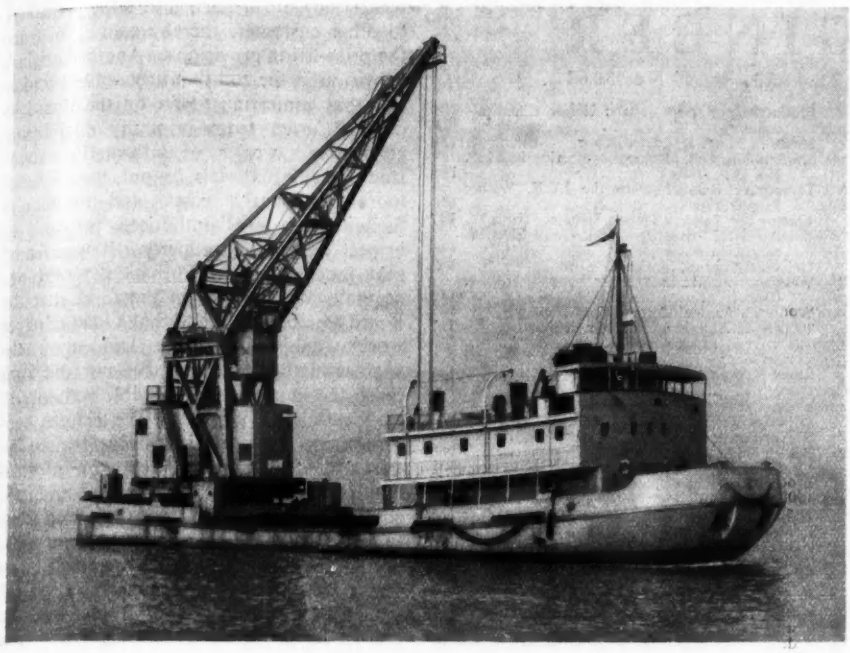
Mersey Ferry "Egremont"

Among the ships completed by the Caledon Shipbuilding and Engineering Company, Ltd., was the "Eddybay," which we illustrated last week. This ship, which was built to the order of the Naval Store Department, Admiralty, was specially designed for bulk oil cargoes and has a long poop, short bridge and forecastle, a length overall of 286ft by 44ft breadth moulded by 18ft 6in depth moulded. She carries 2286-tons deadweight on 17ft 2in load draught at a speed of 12 knots. Lobnitz and Co., Ltd., supplied the enclosed triple-expansion steam engine, which develops 1750 i.h.p. at 227 r.p.m. and takes steam at 250 lb per square inch from two cylindrical boilers provided by the shipbuilders.

In September of last year William Cory and Son, Ltd., took delivery of the motor collier "Corbrae," illustrated on page 135, from the Burntisland Shipbuilding Company, Ltd. The ship has a raised quarter deck and top-gallant forecastle, four large, clear holds, served by self-trimming hatchways and carries 2760-tons deadweight. The main dimensions are: length between perpendiculars 258ft, breadth moulded 39ft 3in, depth moulded 18ft 11in, draught loaded 17ft 6½in. The ship is driven by an eight-cylinder British Polar diesel engine of 1050 b.h.p.

The second of two twin-screw passenger ferries built to the order of the Mayor and Corporation of Wallasey, completed trials in March of last year and was handed over by her builders, Philip and Son, Ltd. The "Egremont," which was described in THE ENGINEER of April 18, 1952, and is illustrated on this page, can accommodate 1472 passengers, while on ferry service across the Mersey, and is equipped to carry 700 passengers on cruising service. Excellent accommodation and amenities are provided for the passengers and the ship, which has a length between perpendiculars of 145ft by 34ft beam by 12ft 3in depth and a load draught of 7ft 4in. Propulsion is by two eight-cylinder Crossley two-stroke diesel engines, each developing 600 b.h.p. at 330 r.p.m.

At the beginning of 1952 the Goole Shipbuilding and Repairing Company, Ltd., completed the Icelandic trawler "Porkell Mani," which has a length between perpen-



Floating Crane "Titan"

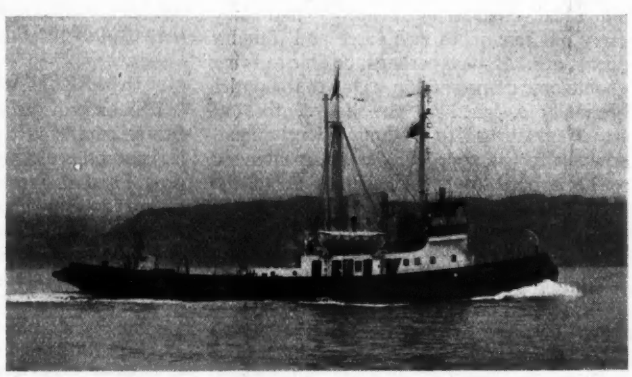
diculars of 185ft, a breadth moulded of 30ft 6in, a depth moulded of 16ft. Power is provided by a six-cylinder pressure-charged Ruston and Hornsby diesel engine developing a service power of 1340 b.h.p. at 435 r.p.m. and driving an S.L.M. reverse reduction gear through a Vulcan-Sinclair scoop-controlled coupling. The auxiliary equipment includes a complete fish-meal plant and a Clarke Chapman electric trawl winch. A full description of the trawler appeared in our issue of February 29th 1952.

Henry Robb, Ltd., constructed a number of tugs during the year, including the "Fourah," to the order of The Crown Agents for the Colonies, for service in the port of Freetown, Sierra Leone. The tug, which we illustrate, has an overall length of 122ft by 30ft beam by 14ft 6in depth and a mean draught of 10ft 9in, and the main propelling machinery consists of two British Polar diesel engines each developing 500 b.h.p. at 210 r.p.m.

The raised propeller, twin-screw diesel pusher tug, "Adama," which will be used as a pusher unit of a waterborne petrol train on the Niger and Benue Rivers in West Africa, was completed by Yarrow and Co., Ltd. Although intended primarily for pushing, the tug, seen in our illustration, is equipped for towing alongside or astern, and her duty is to push a train of eight 200-ton barges over a distance of 1200 miles. The length on the water-line is 123ft, the breadth moulded 32ft, the depth moulded 6ft and draught loaded 4ft 3in, while the propelling machinery consists of two Crossley diesel engines, which give the ship a running-free speed of 10 m.p.h. A special oblique form of tunnel has been adopted to give a more direct lead of water to the propellers, and to increase manœuvrability flanking rudders have been fitted in addition to the steering rudders.

The small tug "Maamel," designed for the Aden Port Trust by the Fairmile Construction Company, Ltd., ran trials towards the end of the year and during bollard trials exerted a static pull of 4·1 tons. The vessel has a length between perpendiculars of 55ft, a beam of 15ft, a depth of 7ft 10½in, a displacement of 68 tons and is propelled by a six-cylinder Blackstone diesel engine developing 270 b.h.p. at 600 r.p.m., and having a continuous rating of 243 b.h.p. The engine drives a four-bladed propeller, working in conjunction with a Kort nozzle, through an S.L.M. oil-operated, 2 to 1 reverse reduction gear to give the vessel a speed running free of 9 knots.

Lobnitz and Co., Ltd., delivered to the Mersey Docks and Harbour Board the twin-screw, self-propelled 25-ton floating crane "Titan," which replaces a crane of the same name, built fifty-six years ago. The crane, which we illustrate, has a tank-tested hull of spoon form and the following dimensions: length 140ft, breadth 42ft, depth 11ft 6in, a working light draught of 7ft 6in and a loaded draught of 8ft 8in. A deck cargo of 120 tons can be carried and propulsion is effected by two sets of open triple-expansion surface condensing steam engines, each developing 400 i.h.p. at 180 r.p.m., and taking steam from two oil-fired Scotch boilers. Two 120kW steam-driven generators supply power for the domestic services and for the crane, which was constructed by Cowans, Sheldon, Ltd., and has a maximum and minimum radius of 60ft and 22ft, respectively. With a 25-ton load the luffing speed is 12ft per minute and the lifting speed 25ft per minute.



Motor Tug "Fourah"

For drilling operations in the deeper waters of Lake Maracaibo a self-contained diesel-electric power barge, "G.P.2," was built by Ferguson Brothers (Port Glasgow), Ltd., for the Shell Petroleum Company, Ltd. This unusual craft was described in THE ENGINEER of September 26, 1952.

Improved Fluorescent Lighting System for Trolleybuses

A NEW method of operating hot cathode fluorescent tubes, developed by the General Electric Company, Ltd., in collaboration with Mr. W. J. Evans, M.I.E.E., M.Inst.T., manager and engineer, Reading Corporation Transport Department, and C.A.V., Ltd., has been on trial since July, 1950, in a Reading trolleybus. Previously the use of fluorescent lighting on a vehicle has entailed the use of rotary inverter or vibrator to derive alternating current from the battery on the vehicle. In this case a 64V battery has been provided and current is supplied to the fluorescent tubes housed in the fittings direct from the battery. The battery is charged by a C.A.V. overhung generator of standard construction, but specially wound for this voltage. A standard C.A.V. control board with a suitable regulator is fitted and so arranged that the legal lighting load is balanced on a three-wire system and the normal 32V lamps can be used for the external lights. Because of the low voltage, special "Osram" tubes, 15in long and 1½in in diameter, rated at 14W each, were used. The circuit comprises a small choke to assist starting with two 24V, 15W tungsten filament lamps in series as a ballast to limit the lamp current to its correct value and to act as a stabilising device to cover variations in battery voltage.

Thermal starter switches are used and in the original installation half the fittings had a relay in series with the starter switch contacts to ensure that tubes were not extinguished during conditions of low battery voltage, which might cause the starter switch contacts to close. In service it has been found that the G.E.C. "OS3T" starter gives satisfactory performance without the relay, which can therefore be omitted.

There are ten fluorescent fittings on each deck, five on each side, designed to be semi-recessed into the body panels. They are constructed with clear reeded "Perspex" covers with opal "Perspex" at the ends to cover the tube holders. The control gear is fixed to the back of the fittings and a small removable cover plate is provided to give access to the starter switch and ballast lamps without having to remove the fitting or panel. The ballast lamps glow on starting, but operate at black heat when running, thus ensuring long life. The only other control gear required is a double-pole change-over switch to reverse the polarity of the supply and eliminate the risk of tube end darkening which otherwise occurs.

Besides the saloon lights, the front and side illuminated destination boxes are fitted with two similar sets of tubes and gear, with the exception of the "Perspex" cover, which is not required for the front box. The rear destination box has been left with the original filament lamps owing to structural difficulties in finding accommodation for the new equipment. The rear platform has a flush-fitting housing one tube and its gear in the ceiling, the resultant projection in the floor of the upper deck being concealed under one of the rear seats.

The resulting illumination gives approximately twice the amount of light previously obtained for no increase in load; the absence of the glare, which exists with the normal small bright filament lamps, is marked.

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ENGINEERING FOUNDRIES AND THE IRON AND STEEL BILL

The majority of engineering firms and many steelfounding businesses as well would undoubtedly prefer that the supervision of the Iron and Steel Board to be set up under the terms of the Iron and Steel Bill should not extend to their works. But though the Government has adhered to its original intention to include the supervision of foundries within the Bill, there will be much satisfaction with the amendments that Mr. Duncan Sandys has tabled for consideration during the committee stage of the Bill. For those amendments will quiet most of the fears engineering firms had that the Board was to be given undue powers to interfere in the way they carried on their affairs. The duties of the Board that could have had relevance to engineering firms under the original terms of the Bill were those requiring it to maintain under review productive capacity, research, the training, health and welfare of persons employed, and joint consultation between producers and persons employed by them ; to fix prices ; and to collect statistical and accounting information. Very naturally, engineering firms looked askance at powers and duties that seemed inappropriately applied to foundries and forges within engineering works primarily intended to supply the needs of those works themselves. It was true that the Board did not need to apply some of its powers to them, but if they were applied —and there was nothing in the Bill to prevent it—some of the Board's activities might cut right across and seriously disturb the general organisation of engineering factories. Furthermore, Schedule 3 of the Bill, which defined "Iron and Steel Activities," failed to distinguish clearly enough between rolling and forging, which are iron and steel activities, and such processes as bending, shaping, pressing, &c., which belong essentially to the engineering industry ; and fears were thus aroused that under a different administration the Board might find an excuse to extend its control to what are more properly engineering activities.

The first necessity, clearly, in amending the Bill was to define more carefully what were to be the fields to which the supervision of the Board should apply. It has been done by redrafting some of the entries under Schedule 3 and in particular by defining those activities that are not to be included within the Board's supervision. In addition, by amendment of the clauses of the Bill itself, it is now specifically laid down that the supervision of the Board over matters of health, safety, welfare and training is not to apply where it can be shown that "the only activities of the undertaking which form part of the iron and steel industry" are the casting of iron and steel "and are incidental to the main activities of the undertaking." Nor is supervision to apply where the Board after consultation with representatives of employers and workers finds that joint consultation forms "part of general arrangements for such consultation applicable to the main activities of the undertaking." The Board is, however, to retain its supervision over research. There, however, its main task, we imagine, will be to encourage the work of existing bodies such as the British Iron and Steel Research Association rather than inquire into the work of individual engineering concerns that may carry out researches into forge and foundry operations. It may, perhaps, be able to bring about some co-ordination. One of the duties originally assigned to the Board, that of requiring firms to submit development schemes for its approval was never intended to be applied to small schemes or to the extension of foundries and the like. But the clauses in the Bill as originally drafted gave grave concern to engineering firms because the limitation was not specifically laid down. Thus, under changed circumstances in the future the Board's powers might have been extended to control the development of engineering foundries. Under the amendments to the Bill the powers of the Board in this respect are specifically not to be applicable to "the casting of iron and steel by any process." Nor is the Board's power to fix prices to extend to castings or forgings except where it can be shown to its satisfaction that a virtual monopoly exists and is being abused. Engineering foundries which, besides supplying the needs of the works of which they are a part, also supply castings to other customers thereby gain relief from the price-fixing provisions. Another original provision in the Bill that aroused opposition was that conferring power on the Board to demand, even from primarily engineering concerns, a wealth of information about stocks of raw materials, output, capacity and, more particularly, costs, and to require facilities for an "authorised person" to inspect books and property. It was feared that much of the information would not normally be available in the form that the Board would need it, and that a load of paper work would thereby be laid upon the engineering firms concerned ; nor did firms relish the inquiries and possible activities of an "authorised person." The clauses concerned are now to be wholly revised so that a distinction is drawn between information about production on the one hand, and costs, on the other. It is held that, adequately to do its duty, the Board must have information about production ; but there will be no power, save in special circumstances, to call for information about costs from foundries. The power to inspect books and property is removed except where it is necessary for the enforcement of decisions on development and prices.

As a whole engineering concerns would much prefer to see their foundries excluded from the supervision of the Board. But that unanimity does not extend to more independent iron and steel foundries. In those circumstances the Government's view that without giving the Board supervision of all foundries it could not satisfactorily do its job must prevail. Moreover, it cannot be regarded as certain that the complete exclusion of foundries from the Board's supervision would really benefit the engineering industry. For, as Mr. Sandys recently pointed out, foundries consume as much as about one-quarter of the country's total supplies of pig iron and scrap. Were a scarcity to arise, could a Board excluded from supervision of the foundries give adequate and sympathetic consideration to their needs ? Certainly, short of the complete exclusion of engineering foundries from the Board's supervision, the proposed amendments seem to go about as far as they possibly could towards meeting the objections raised against the terms of the Bill as originally drafted.

LONG-TERM DEFENCE PLANNING

It is only in the past few months that the British people have been informed by Ministers and others in authority of the remarkable progress that has been made since the war in the development of the guided missile. Concurrently, official information has been released in the United States of the successful application of atomic explosives to conventional weapons. Details and photographs are now available of a 280mm Army gun, which fires atomic shells—a gun which has a range of 20 miles, great accuracy and which, once in position for firing, can be elevated and trained by hand. These are revolutionary developments and must make very difficult, if not impossible, the preparation of long-term defence plans. For the future of almost every type of present-day ship, aircraft and weapon hangs in the balance. The technological-military revolution now in progress is, indeed, without precedent

and may well provide an additional reason for the Government's decision to peg back our annual expenditure on defence production to £600 million—a figure substantially below the sum planned in the 1951–54 £4700 million rearmament programme.

Atomic power plants for the generation of steam for turbines will also have an important bearing on the design if not on the types of ships to be built in the future. Two atomic power plants have been ordered for United States submarines and, according to Mr. Kimball, Secretary of the U.S. Navy under the Truman administration, the third, or in any event, the fourth, of the ten 60,000-ton aircraft carriers which the Navy hopes Congress will approve (two have already been authorised) is also to have an atomic power plant, the contract for which has been placed. Nor can it be long before the Army 280mm atomic gun is adapted for naval purposes and this may well introduce a radical change in the whole conception of sea warfare, as at present envisaged—protection of sea communications against attack by mine and submarine with the striking power of the Navy concentrated in the aircraft carrier to carry the offensive into enemy waters. The Army atomic gun, stripped of the front and rear tractors between which it is suspended for transport, is not much larger than the heaviest field piece now in service and the Russians may well build ships of the size required—or reconstruct their improved " Kirov " class heavy cruisers —to carry it as their main armament. Fleet actions between surface ships might well follow, with a new type of small expendable battleship as an essential requirement, the carrier, perhaps, reverting to her original role of assisting to gain and maintain control of surface sea communications, in addition to operating anti-submarine aircraft. While, however, there will always be a function for the smaller class of carrier in naval operations, the future of the large carrier seems likely to be decided by the success achieved in the further development of the guided missile. The rival claims of the U.S. Navy and Air Force about the best agent for strategical bombing seem to have been settled temporarily in favour of the medium-range bomber operating from 60,000-ton carriers. But other authorities consider the large carrier is primarily required—and this may be said to be the British view—to provide air cover in the initial stages of a combined operation pending the establishment of Air Force bases ashore. Yet so rapid has been the development of the guided missile, that many experts now believe it will replace altogether the interceptor fighter and the long and medium bomber, within a period between ten and twenty years. The guided missile consists of a warhead propelled by a rocket, or by a combination of rocket and ram-jet, and can either be guided from the ground by radar and electronic devices or launched and " homed " on its target without aid from the ground. As an anti-aircraft defence missile it is already in an advanced stage of development and is in quantity production in the United States. It has a rate of climb, speed and altitude which the piloted fighter cannot hope to attain and, unlike the interceptor fighter, whose pilot is subjected to considerable strain when manœuvring at high speeds, it can be turned sharply at its maximum speed.

Offensive operations require a missile with a very much longer range, travelling beyond the atmosphere. Guiding and homing principles can equally well be, and are being applied to the long-range rocket but much more investigation and research are required—notably to determine the best kinds of fuels to be used—before it can be regarded as a reliable long-range offensive missile. Long-range guided rockets have, however, been successfully launched in the United States with speeds of over 4000 m.p.h. and two United States cruisers are being reconstructed—no doubt for experimental purposes—for the installation of a main armament of rocket-launching platforms. It can thus only be a question of time—a time not far distant—when the long-range guided rocket, with an atomic warhead when required, will replace almost entirely the piloted bomber, which is already finding it difficult to penetrate existing anti-aircraft defences equipped with radar warnings and interceptor fighters. In that event ships no larger than a cruiser firing long-range rockets may well replace both the huge intercontinental " B-36 " bomber and the giant carrier now required for operating the medium-range bomber. That is, of course, not to say that there will be no future requirement for military aircraft. The R.A.F. will still require reconnaissance aircraft for operations over land and sea and the fighter-bomber for the tactical support of troops. Equally, the Royal Navy will still require anti-submarine aircraft and the naval fighter, not only for dealing with hostile reconnaissance aircraft shadowing a convoy at sea, but to provide aircraft cover in the initial stages of a combined operation. But present developments do certainly suggest that there may be little need for other kinds of aircraft and that a limit may be placed on the size of the future carrier.

Obituary

SIR JAMES FRENCH, D.Sc.

We record with deep regret the death of Sir James Weir French, which occurred on January 14th, at his home at 998, Great Western Road, Glasgow. Until his retirement in 1949, Sir James was chairman of Barr and Stroud, Ltd., of which firm he had been a director since its inception in 1913.

James Weir French, who was born in 1876, was the son of Mr. Andrew French, a metallurgical specialist. He received the earlier part of his education at Bearsden Academy, and later studied at the University of Glasgow, where he subsequently received his D.Sc. degree, and at the Royal Technical College, Glasgow. Sir James continued his studies in several centres abroad, including Berlin, where he took particular interest in German scientific instrument making. From the beginning of his distinguished engineering career Sir James specialised in the design and development of scientific instruments, and prior to the first world war had made some important contributions in the field of range-finding instruments and gunsights. It was this work that led Sir James to join the late Dr. Archibald Barr and Dr. William Stroud. When their instrument manufacturing partnership became a limited company in 1913 Sir James was appointed to the board, and for the remainder of his life was closely associated with that company's development and progress. On Dr. Stroud's appointment as chairman in 1931, following the death of Professor Archibald Barr, Sir James became vice-chairman, and seven years later, when Dr. Stroud died, he succeeded to the chairmanship of the company.

Between the wars Sir James gave close attention to the design and development of instruments necessitated by the rapid progress in aircraft and submarines. He held many hundreds of patents for range-and height-finding instruments, periscopes, gunnery control equipment, and anti-aircraft sights, the invention of all of which involved not only an expert knowledge of metals, but also of glass and its manufacture. In this latter connection, it may be said, Sir James was deeply interested in the artistic as well as in the technical aspect of glass. He was a Fellow of the Society of Glass Technologists and was also the lay president of the Glasgow Art Club. During the second world war his firm made a notable contribution by the supply of the many and varied instruments that were essential to the success of the fighting services, and in recognition of the scientific work that he had accomplished Sir James was created a Knight in 1941.

Sir James retired from the chairmanship of Barr and Stroud, Ltd., three years ago, but continued to take a keen interest in its affairs and in the affairs of the scientific and other societies of which he was a member. These included the Physical Society, the Institute of Physics, the Institution of Engineers and Shipbuilders in Scotland, and the Royal Philosophical Society of Glasgow. Sir James was the author of many books and papers dealing with optics, optical glass, and the science of instrument making, and also with the economic aspects of industry.

Sir James took a lively interest in the education of the young. But some of his views were not very popular. He held for, instance, that many boys, instead of being educated up to fifteen years of age and possibly going on with their education thereafter, would be much better suited by entering an engineering works earlier. He maintained that for those without academic attainments experience in a works was a better education and fitted them better for after life. His views on other topics were equally independent, with the result that it was always entertaining and usually enlightening to talk with him, and his charm and his generosity won him many friends outside as well as inside the technical fields of which he was a master.

JAMES WHITCHER

We have learned with regret of the death, on January 12th, of Mr. James Whitcher, of 7, Manor Road, Ruislip, Middlesex. Until his retirement in 1947, Mr. Whitcher was senior electrical engineer on the staff of Messrs. Kennedy and Donkin, consulting engineers.

James Whitcher was born on April 10, 1871, and was educated at private schools on the Isle of Wight and at Finsbury College and King's College, London. He spent a period of practical training with J. D. F. Andrews and Co., of Westminster, and was then, for a few years, a supervising engineer with Messrs. Lea and Warren. In that position he was engaged mainly on the steam and electrical equipment of factories in various parts of the country. In October, 1902, Mr. Whitcher joined the design engineering staff of the British Thomson-Houston Company, Ltd. He remained with the firm for the next seventeen years, during which time he was concerned with the design of apparatus and the planning of station and switchgear lay-

outs and systems. Mr. Whitcher was appointed to the staff of Messrs. Kennedy and Donkin in 1919, and, as the firm's senior electrical engineer, dealt principally with research and design matters. He was called upon for advice in connection with contracts that involved the application of new electrical developments. In his early years with Kennedy and Donkin Mr. Whitcher was closely concerned with the electrification of the south-eastern section of the Southern Railway. Other work to which he gave much attention was that associated with the design of substations and transmission lines for the Central Electricity Board.

Mr. Whitcher retired from active participation in the practice of Kennedy and Donkin in 1947, though he was retained as one of the firm's consultants. He was elected an Associate Member of the Institution of Electrical Engineers in 1902 and a Member in 1934.

BRIGADIER-GENERAL MAGNUS MOWAT, C.B.E.

As we go to press we have learned with great regret of the death of Brigadier-General Magnus Mowat, C.B.E., M.I.Mech.E., which occurred, suddenly, at Ebor House, East Sheen, S.W.14, on Monday, January 19th. General Mowat, who was seventy-seven, was secretary of the Institution of Mechanical Engineers for eighteen years until the end of 1938, when he retired from that office on account of ill-health.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SIMPLICITY IN GEARS

SIR,—Your leading article of November 21st, on the above subject, drew attention to a paper by Professor Tuplin in which he forecast the appearance of revised British gear standards embodying his proposals. The general discussion of future British standards while they are still in the committee stage appears to be a new and perhaps not always a wholly desirable thing, but in this case a widened circle of comment could be salutary.

It is well known that in the field of toothed gears the smallest technical problem is likely to breed opposing schools of thought amongst the *cognoscenti*. The discussion of such technical problems would be inappropriate to your ocrrespondence columns, but there are certain broader questions to which those for whose benefit the specifications are presumably designed might usefully give some thought.

The object of most British standards is to lay down dimensional standards by which interchangeability and the avoidance of unnecessary variety may be promoted, and standards of workmanship defined. In the field of gear manufacture, there is little scope for so doing. It may be a proper objective in the case of some classes of gear-cutting tool, but whether standardisation should be applied to the detail design of gears is questionable on both commercial and technical grounds. Commercially, it is unusual (and usually unwise) for mating gears to be manufactured in different places; if interchangeability of intermating gears from different sources were required, it would need closer control than could be exercised under the clauses of a British standard specification. Technically, there is no factual evidence that one system of detail tooth design is better than another (glaring errors excluded), although future research may provide criteria. If the giving of rules for detail design is to be continued in future British standard gear specifications, they merit, at most, the title of "recommended practice." From any such rules, competent gear designers would confidently depart if they thought fit.

The pseudo-textbook air of the specifications is carried further by the inclusion of formulæ for horsepower rating. To my knowledge no other British standard specification aims to tell an engineer how to design machinery, or virtually to guarantee its performance. The performance of gears is influenced by a multitude of factors, few of which are really understood, and to give rules or formulæ without explaining the underlying assumptions and without comment on the possible effect of variables (such as rigidity of mounting) not covered by the specification is to achieve only the delusion of simplicity.

As it happens, gears designed in accordance with British standard rules are generally satisfactory; but this means only that the margin of safety more than covers the errors and omissions in the rating formulæ. That margin, it is safe to assume, varies greatly from one design to another, and it is too much to hope that one set of formulæ and factors can lead to equal economy in the use of material over the whole range of gear designs.

Instead of replacing one doubtful rule by another, therefore, it would be more timely to re-examine the proper role of British standard gear specifications and to determine, more clearly and precisely than appears to have been done, the policy which shall govern the scope and substance of those specifications. As now cast, either they may be used improperly to invoke the authority and support of the B.S.I. for questionable technical practice, or the imperfections of these publications of the B.S.I. may cause damage to its prestige.

H. E. MERRITT

Coventry,
January 12th.

Comment on Automatic Train Control

By W. A. TUPLIN, D.Sc., M.I.Mech.E.

THE railway collisions at Harrow on October 8th have drawn attention again to devices for bringing the aspect of a fixed signal forcibly to the engine driver's notice, because it seems probable that such a provision would have avoided this accident. The brakes of the Perth train were applied just before it struck the stationary train and the driver was found in the normal driving position after the accident. The probability is that some footplate incident had distracted his attention from looking ahead for a period that caused him to miss observation of the Harrow distant signal and two stop signals nearer to the station. An audible cab signal as he approached the distant signal would have warned him that there at least he should be looking out. It would not require a brake application, but only an audible warning, to recall a driver who was dozing, woolgathering or coping with some footplate emergency or, failing these, to attract the attention of the fireman. If, however, it is desired to safeguard against the results of incapacitation of both men, the warning must be supplemented by automatic application of the brakes.

When automatic train control is discussed, attention is naturally directed to the old-established system used with great success on the Western Region of British Railways. It is easy to think of more elaborate systems than this, but it is much more to the point to consider whether something even simpler will suffice. In the Western Region system, mechanical contact of a shoe on the locomotive with a fixed ramp on the track is combined with electrical circuits, including an accumulator on the engine and another on the ground near each ramp. Passage of an engine over a ramp is accompanied by one or other of two kinds of audible cab signal according as the associated distant signal is showing "caution" or "clear."

It is notable, however, that despite the use of A.T.C., Western Region drivers are required to observe the fixed signals in the usual way and fog-men are posted at distant signals during fog. In essence the Western A.T.C. warns the driver that he is approaching a distant signal and if the signal is showing "caution," begins to apply the brakes with increasing force until the driver acknowledges the warning by resetting the apparatus to the normal running condition. If the signal is at "clear" the A.T.C. gives a different audible indication that the engine has just passed the leading end of a ramp, but no brake application is made.

There is no need for A.T.C. to inform the driver of the aspect of the distant signal, as it is his duty to discover it by visual observation or, failing that, to assume its aspect to be "caution." The only essentials are a timely reminder to look out and (in case the reminder is ignored) a rapidly increasing brake application that needs manual cancellation. Safe routine is that the driver should not cancel the automatic application until he sees the associated signal, whether it be a semaphore or colour light, yellow or double yellow. If this be accepted, there is no need for A.T.C. to distinguish between "caution" and "clear," and electrical equipment becomes superfluous.

An audible warning and a brake application can be produced by purely mechanical and pneumatic means and the consequences of physical contact between a member on the track and another on a fast-moving locomotive are shown by Western Region experience to be much less severe than might be supposed. Maintenance cost of the mechanism of the Western A.T.C. is negligible despite the fact that the sliding shoe must be held on the ramp by heavy spring pressure in order to prevent interruption of an electrical circuit by bouncing of the shoe after the initial contact with the ramp. An A.T.C. system without electrical devices would gain by avoiding any need for heavy spring pressure on the shoe and by being unaffected by ice or snow.

A feature of a system that does not distinguish between the aspects of the distant signals is that the driver must reset the apparatus promptly at every such signal if the brake application is not to become perceptible. This involves a little more labour than with the Western Region system, but it has the advantage (from the viewpoint of safety) that the driver must be in the driving position at each distant signal. Experience has shown that some drivers resent the discipline of A.T.C. and are prepared to make it ineffective by jamming the acknowledging handle in the resetting position or by blocking the air inlet. The former folly is circumvented by arranging the apparatus so that air is admitted to the train pipe by a special valve so long as the handle is in the resetting position and the latter by placing the apparatus outside the cab so as to be inaccessible when the engine is in motion and so as to make the warning sound audible outside the cab as well as inside.

A difficulty about any automatic brake application is that of making it strong enough to stop a heavy fast train before reaching the home signal and at the same time not so violent as to lock the braked wheels of the locomotive when running light or hauling a freight train without vacuum brakes. This condition of compromise, or a satisfactory approximation to it, has been achieved in the Western Region A.T.C.

Mechanical simplicity, apart from being generally desirable (especially in safety devices) is vital to the attainment of low cost. The maximum economically tolerable running cost of an A.T.C. system may be estimated from a knowledge of the cost incurred in (say) the last fifty years by all the accidents that A.T.C. could have been expected to avoid. On this basis the figure of £10 to £15 million mentioned in the daily Press as the estimated cost of installing a particular form of A.T.C. throughout British Railways is probably prohibitive. Interest charges, depreciation and maintenance of equipment of such capital cost would be likely to exceed £500,000 per annum and it is doubtful whether, over a period of years, the cost of accidents avoidable by A.T.C. on British Railways averages as much as this.

A capital sum of £10,000,000 seems excessive even if it covers every locomotive and every distant signal on British Railways. It is of the order of £500 for one locomotive and one signal. The essential features of A.T.C. can be provided at a much lower cost than this if there is a genuine desire to install it.

Control Valves for Direct-Hydraulic Presses

THE INSTITUTION OF MECHANICAL ENGINEERS

AT a meeting of the Institution of Mechanical Engineers last Friday, January 16th, a paper "Control Valves For Direct-Hydraulic Presses" by F. H. Towler, M.I. Mech.E., and J. M. Towler, M.I.Mech.E., was presented and discussed.

Summary

Some direct-hydraulic presses have become very complicated due to the introduction of servo-electric controls, embodying a mass of electrical fittings, solenoids, micro-switches, &c. In this paper a new, completely hydraulic control system is described which entirely replaces the electrical controls, thereby bringing all maintenance problems within the scope of the hydraulic engineer. Also, with the elimination of electrical time-delays, it is possible to ensure almost instantaneous valve action. The paper deals briefly with "packingless" piston valves, the avoidance of various forms of lock, and the problems involved in the design construction and control of large hydraulic presses, the choice of the most advantageous working pressure, and the viscosity of the hydraulic oil.

A detailed description is given of a 1000-ton direct-hydraulic forging and planishing press, powered by high-speed pumps totalling 665 pump horsepower and controlled by a single-lever, completely hydraulic, remote-control panel. This press makes reversal in one-tenth of a second, making short planishing strokes as lively as a pneumatic hammer. In conclusion, controls and multiple power units for much larger presses are discussed.

Discussion

Mr. V. A. Skinner proposed to deal first with the press which had been seen in motion in a film shown by the authors at the meeting. The paper contained a drawing of the control valves. He was particularly interested in the design and arrangement of the decompression valve, the valve designed to release the pressure before reversal. He would like to hear the comments of others on that design as he felt that it was rather complicated and very difficult to service as it was incorporated in the prefill valve itself and part of it was actually within the actual cylinder cavity. The more orthodox type of pressure exhaust valve, which was usually mounted in the external piping, was much more easily serviced and much more easily maintained and adjusted. He felt that the type of valve shown in the paper might lead to trouble, perhaps due to spring breakage, and it could cause a lot of damage which would not otherwise occur.

The paper mentioned the advantages of using fully hydraulic control to perform the operations one normally expected with electrical control, but doing it without any solenoids or push buttons and instead doing it purely hydraulically. He felt that such a method of operation had many advantages. They all knew how, in practice, when trouble occurred on a press in a large factory, the maintenance electricians and the hydraulic men would play off one against another, which led to a considerable loss of time. The method proposed in the paper put the whole thing in the hands of one department or one individual. However, he felt that it might be more expensive, and he certainly could not see that it simplified the hydraulic side of the installation. He also felt that the more orthodox type of control circuit, which was operated by limiting switches through the ordinary solenoids, was much more flexible. It lent itself to minor changes in control functions and cycle changes in the press which might be desirable at some later stage to suit the requirements of a customer, and such alterations would be rather difficult to achieve with the pure hydraulic control.

The subject of oil viscosity had also been dealt with. While he agreed wholeheartedly with the authors about the advantages of low viscosity oil in reducing pipe and valve sizes and enabling higher pipeline velocities to be used, he felt that there was one point which had not been mentioned, and that was the difficulties which arose in manufacturing hydraulic equipment when one used a very low viscosity oil. Of necessity, clearances must be very much closer and manufacturing tolerances must be very much tighter, and he felt that there would be some greater chance of wear in the way of scoring through the presence of minute inclusions in the oil than there would be when one used a valve designed for a higher viscosity oil. Also, the low viscosity oil meant that one had to maintain closer working tolerances in rams and pistons. He felt that in the orthodox type of double-acting piston, slip would be a rather serious consideration, and it would almost lead one into designing a press with single-acting rams, which, again, might make the installation more expensive. There was also the question of the combination of higher working pressures together with a low viscosity oil. The authors had mentioned that in their cylinder design they worked to fairly high stresses in the cylinder wall. That would lead to increased expansion in the cylinder when it was under pressure, with a consequent increase in slip.

He felt that the subject of stored energy for peak horsepower requirements was one of importance in view of the current tendency for ever-increasing press tonnages. One of the most serious objections met in selling the hydraulic press as against the mechanical press was the requirement for a very large horsepower motor. It was often in the region of 400 h.p. or 500 h.p. as compared with the 40 h.p. or 50 h.p. motor required for the mechanical equivalent. He felt that there was a good case for developing some suitable form of stored energy to cater for the usually very small period of high horsepower. The paper contained a diagram of a pump which was equipped with a flywheel. It seemed to him that such an arrangement had its limitations. A mechanical press was usually designed for a certain working stroke, a rather limited working stroke. On the other hand, the hydraulic press was usually designed for a fairly wide range of working strokes and might at some future time be used for all sorts of operations for which it was not originally designed. Any form of stored energy which had to be given out during the working stroke must, therefore, be related to the period over which that large horsepower was required. It seemed to him that there were many difficulties ahead in designing a suitable form of stored energy.

Mr. R. Hadekel said that except for aircraft, where the weight aspect, of course, formed an easy criterion, he did not believe that there was any simple way of deciding upon optimum pressure, although there was a general law to the effect that the higher the power involved the higher the pressure should be, and that was borne out by actual equipment which roughly followed that law. No doubt the high pressure chosen for the machinery described in the paper was not far off the optimum for the case in question, but that should not leave them with the impression that there was some special virtue in 4000 lb per square inch for hydraulic equipment in general. Indeed, he was sure that the authors would not deny that for machines not exceeding a few hydraulic horsepower the optimum pressure might range from 3000 down to as low as 100 lb per square inch or even less, depending upon the power and certain other factors. A similar case could be made out concerning the contention of the authors that viscosity should be very low ; the choice of viscosity was in fact governed by many considerations, of which the authors mentioned only one, namely, pressure loss in pipes. Furthermore, a comparison based on losses with oils of different viscosities in a pipe of given size was misleading, and it would be more significant to compare the pipe size required to limit the loss to a given figure ; since loss varied inversely as the fourth or fifth power of pipe bore, an appreciable increase in viscosity could be accommodated by quite a small increase in pipe size.

He could not agree with the analysis of hydraulic lock made by the authors. First, the very term, although generally accepted, was misleading, since lock implied an impediment to motion which could be overcome only by breaking or straining some component, whereas the phenomenon in question was merely a friction effect which determined the load required to operate a valve ; except in a few cases, such as sensitive servos, that load was not large enough to worry about, and merely formed a criterion for the strength of return or centring springs. The statement that hydraulic lock was less likely to occur the smaller the clearance, was, he thought, contrary to all that had been found out about that phenomenon. Apart from dirt effects, it had been shown by Sweeney and others that hydraulic lock was due to departures from theoretically perfect surfaces, such as taper, ovality, curvature of centre line, and any other manufacturing errors.

Mr. G. Orloff said it was refreshing to read the remarks of the authors regarding the benefits derived from high pressures. In the field of aircraft hydraulics there had often been made in the past similar statements and a lot of comparative weight estimates between low and high-pressure systems, and each time it had been possible to convince people that a system with a 4000 lb per square inch working pressure was lighter than one using 3000 lb per square inch. The main objections to the use of such a system had in the past been lack of experience and the risk of worse reliability.

Mr. A. F. Marshall wanted to know what oil was used on the Towler pump. He wondered whether it was the normal oil or whether, in view of the heavy nature of the duty, an oil of slightly higher viscosity would be an improvement. He would also like some information of the fire risk, although it was probably negligible. He also wished to know whether, after the use of the press for eccentric loading, there was any serious leakage of the fluid from the ram which might cause any trouble. As a point of interest, a similar kind of control gear was being installed in a 5000 or 6000-ton press in Canada which was also using oil as the working fluid, but it had three large slow-speed pumps instead of five smaller Towler pumps, and the operator was able automatically to control the speed by cutting in and out the delivery from the three large pumps.

Mr. Donald Firth remarked that he proposed to confine his remarks to the one point of cavitation. He drew attention to the

fact that the paper stated : " With very high velocity there is a danger of cavitation, accompanied by noise and instability. This may also cause erosion." That statement was rather bald and a little misleading. Cavitation was not necessarily a product of high velocity as stated, but was the product of local pressures in the fluid falling below the fluid's vapour pressure. It was important there to distinguish between the phenomenon of cavitation and that of cavitation damage, which sometimes, but not always, ensued. Cavitation was the formation of vapour bubbles in a fluid. Cavitation damage resulted from the impression of such bubbles on the machine working surfaces. Much work had been done on the mechanism of cavitation and cavitation damage and much more remained to be done, and he believed that it was now being done on an ever-increasing scale. Whilst he had known oil systems working under cavitating conditions, he had never yet seen any cavitation damage of the kind characteristic of cavitation damage arising from water. Experimental work on cavitation tended to confirm the apparent reluctance of oil to cause cavitation damage. An experimenter using a magneto-striction device found on a comparative basis that in test runs of 120 minutes' duration using the same material the specimen lost 190mgm of metal due to cavitation damage when operated in distilled water against a loss of only 1·2mgm when operating in mineral oil. That was so small as almost to suggest that the loss was due to something else and not cavitation.

In most high-pressure hydraulic systems it was staggering to consider the rates of dissipation of kinetic energy through the exhaust valve into the filling vessel. Uncontrolled operation of those valves could often cause violent shock in the system and a considerable amount of quite terrifying noise. The future extension of high-speed working inevitably came back to how fast that valve could be operated with a minimum of shock and vibration. An experimental investigation of the problem would be extremely useful. One particular danger in such a system, particularly where there was a free air boundary, was the possibility of considerable oil aeration due to turbulence. Once aeration had taken place, the efficiency of the press diminished rapidly due to the change in the build-up pressure time caused by the increased compressibility of the fluid when aerated. Future valve developments might be arranged to form a centrifuging flow which would tend to throw out the air in the vortex formed by the flow.

Mr. D. A. H. Alexander had some misgivings about the universal replacement of electrical control by hydraulic control, but nevertheless felt that all engineers who were concerned with the design or maintenance of automatic or semi-automatic direct-hydraulic presses would welcome the endeavour of the authors to achieve simplification. In the case of the 1000-ton planishing press, the all-hydraulic method seemed to be an economical solution. But many of them were concerned with presses of much lower tonnage, and they wondered whether it would not prove a much more costly proposition to substitute valves for switches, especially in the smaller sizes. They often adopted solenoid operation of valves to enable them to interlock guards or moulds with press control. It was their experience that valves usually needed far more effort and travel to operate them than did switches. If the press designer was to go over to all-hydraulic control, there seemed a need for smaller valves to be available to him at a reasonable price and on quick delivery. Sometimes one had to add something to a press to suit changing circumstances ; a switch was easily put in, but one had to wait for a valve. He wondered if all operations which could be achieved electrically could be achieved as reliably and easily by hydraulic means. He had had experience of short dwells of two to five seconds where sustained pressure pumps were not desirable. He had tried a thermal type of electric delay, but that had proved unreliable on a quick repeating cycle for it did not cool down in time. He wondered if a hydraulic delay was reliable in a circuit where the viscosity of the oil would change with temperature even with oils having a very flat viscosity temperature curve and a high viscosity index.

He thanked the authors for mentioning the flywheel accumulator. Others had called attention to it. Was it a fact that it was only useful when the pump was supplying one cylinder at a time ? They often used an accumulator to supply extra fluid to meet a peak quantity demand so that the system had available the delivery of both accumulator and pump, with only a limited pressure drop. The addition of a flywheel to a pump unit appeared only to afford a higher pressure to meet a peak pressure demand, and as the flywheel gave up its energy by reduction in speed there must inevitably be momentary reduction of pump output. Perhaps in the case of the application which the authors had in mind its advantages were overwhelming. It might mean a smaller motor, in which case it was probably an advantage.

Mr. J. Dodson felt that it would be helpful if they might be given some idea of the economics of the all-hydraulic and the more conventional servo systems which were in general use.

Mr. D. C. Sweeney commented on the statement in the paper that hydraulic lock was less likely to occur the nearer a condition of zero clearance was approached. From theoretical reasoning, the transverse thrust on a piston in a cylinder bore, arising out of deviations from the ideal cylindrical form, depended on the magnitude of those deviations relative to the clearance between the surfaces. Therefore, the smaller the clearance the better must be the dimensional accuracy and truth of the components in order to minimise lock. He would be surprised if, in general, in any of the valves belonging to the authors which were subjected to the same degree of lapping those having the smallest clearances also exhibited the least amounts of lock. With fine clearances a very high degree of accuracy of the surfaces was necessary to ensure an absence of lock, and it might be worth remembering that lock arose only when the surface errors were such as to produce a clearance which diverged towards the low-pressure end. If it was practicable to provide a taper of the opposite sense—and that need only be very small—a centralising force was generated and lock thereby positively obviated. In that connection, he might mention that work on hydraulic lock was being continued at Birmingham University, and it had as its immediate object the correlation of lock with axial taper, both theoretically and experimentally.

Mr. H. G. Conway remarked that in the film which had been shown a lot of pressure gauges had been seen. The presses were designed to last year in and year out, but how one could expect any pressure gauge to continue fluctuating at the rate shown in the film for long periods was beyond him. How did one get gauges to stand more than a few hours under such conditions ? With regard to hydraulic lock, the excellent work being done at Birmingham and also at Manchester had been mainly confined to low pressures. He would implore Mr. Sweeney and his friends to get their research put on a better practical basis and so give them the results of work done at higher pressures. What occurred at 100 lb per square inch was unlikely to be very relevant in respect of a pressure of 3000 lb per square inch. Surely there were now synthetic fluids which were used in die casting machines which could be used for presses instead of oils which had serious fire risks ? What had been said about cavitation with water and with oil had interested him. Many fluids were water based. It would be interesting to know whether a fluid which was 50 per cent water would cavitate like water or like oil.

Another speaker said that he had recently been occupied on the installation of large hydraulic plant for railway wheel forging, and in considering control gear for the presses he was very much concerned about maintenance problems. For an 8500-ton press, water appeared to be the only practicable medium of hydraulic power. The size of the plant and the high operating speeds of 12in per second approach and 3in per second forging made it advisable to locate the main valves in positions such as would simplify the main pipelines. By using electrical control equipment it was possible to seat one operator at a control desk and place the whole of the controls of the press and its auxiliaries at his command, thus enabling him to do what had formerly been the work of four men, which was a considerable saving. That was achieved by a combination of electrical equipment and oil and water control valves. But—here he differed from the authors—what appeared to be a very complicated set-up was actually composed of very simple standardised elements which could be bought off the shelf.

He did not altogether agree that bringing complete hydraulic control within the scope of the hydraulic engineer simplified maintenance. It might in the case of planned or schedule maintenance, but experience indicated that it was wise to make emergency maintenance easy, and that fell into three stages—location of fault, where it was not obvious ; readjustment or stripping and replacing of the defective unit ; testing out on completion and resumption of work. Fault finding could be a very lengthy process when the fault was not obvious. On new equipment which was the first of its kind it was not easy to arrive at a reliable overhaul schedule. With the set-up which he had described, it was a very easy matter to close the main stop valve and test out the operation of the electrical system, pilot valves and main valves in sequence without operating the press. He had found that the electrical equipment gave little trouble.

Mr. J. M. Towler, replying to the discussion, said his firm had used prefilling valves of the type shown in the paper for something like twenty years, and he had no hesitation in saying that it was almost the last thing which ever gave any trouble. He had known such valves installed for seven or eight years without requiring to be looked at. He felt that with a mechanism like a prefilling valve there was not much excuse for having spring breakage. It was a mechanism with lots of room to enable a sufficient volume of steel to be put in to keep the stress down to a reasonable figure. Furthermore, there was the contrast between water and oil. The springs undoubtedly gave a great deal of trouble in water hydraulic systems, and he supposed the reason for that was corrosion fatigue. The subject of erosion at very high velocities had been raised. No erosion effects

had been noticed. Rather would they be expected in the decompression valves. The reason there was no erosion there was probably due to the fact that the operating cylinder pushed each pair of valves about ¼in off their seats very rapidly, after which there was a gap to enable the oil to escape and so pass to the next pair of valves. Therefore, one did not have valves very close to their seats with oil passing through at very high velocity, which seemed to him to be the most common cause of erosion. He would add that his company had never been able to make a seated relief valve to be really satisfactory. By "really satisfactory" he meant one able to run for six months with the pressure due to its action not varying more than 3 or 4 per cent. One never knew at what pressure a seated relief valve would blow. The only thing one knew was that after it had been working for a few hours it would leak at any pressure.

He wished to make it quite clear that his company did not think that all-hydraulic controls were going to replace every sort of electrical control of hydraulic presses. The field which seemed to them to be most fruitful was that of relatively simple presses with simple cycles which worked very rapidly. The reason was that that was a field where the electrical switch, solenoid and contactor, all wore out fairly rapidly, and in rapidly acting presses delays in the operation of switches, relays, contactors and solenoids became a matter of very great importance. He had not made any measurements of the times required for the operation of relays and contactors, but he was informed by one of the electrical manufacturers that a relay would seldom operate in less than three cycles and a contactor seldom in less than ten cycles. Delays of the order of a fifth of a second were of great importance, especially in presses which were reversed by the pressure rise. In the press described, the pressure was rising at the rate of about 9000 lb per square inch per second, so if one wished to control the reversal of the ram by the pressure it was necessary to have a very consistent mechanism to respond to the pressure, and by its very nature the a.c. relay was inconsistent and depended on the part of the cycle in which it was operated.

Mr. Skinner had referred to the question of heavy oil versus light oil. He considered that Mr. Skinner exaggerated the difficulty of manufacturing valves to give very little slip with light oils. Certainly he himself had never regarded that as being particularly difficult, and, to his mind, there was no evidence that wear was any greater.

He had never been able to understand why mechanical presses were invariably fitted with flywheels and yet hydraulic presses to do exactly the same work would have motors of the full horsepower. That seemed ridiculous when one considered that the efficiency of the transmission between the motor and the tool was higher in the case of the direct-hydraulic press than in the case of the mechanical press. People had some idea that the energy which could be taken out of a flywheel could only be taken out dynamically; it could be taken out in the same way as from any other storage system.

No matter what the theoretical considerations might be about hydraulic lock, he had found that unless a very large clearance was resorted to, giving an excessive leakage, a minimum clearance in practice resulted in less lock. He would not necessarily say less hydraulic lock; it was difficult to distinguish between hydraulic lock and dirt lock, and he did not know how to do it.

Mr. Conway had referred to non-inflammable fluids, and a number of speakers had referred to fire risks. Non-inflammable fluids had two very important disadvantages. One disadvantage was that most of them had a higher density than oil, in some cases a density of 1·3—he remembered a density of 1·6 in one case—as against about 0·9 for oil. That made them much more difficult to pump; one required much higher pressures to accelerate the columns of fluid. The other disadvantage was high cost. He was convinced that in a press like the forging press it would be easy to put a removable sheet steel trunk round the pipe which, in the event of a burst pipe, would merely deflect the oil down a drain. The cost of doing that would be very much less than the cost of one fill of non-inflammable fluid or one fill of oil.

Emulsification and aeration had also been referred to. It was known that no measurable aeration occurred in the press in question. They had measured the output of the pumps when the press was running, by the rate at which the return rams were pushed back, and there was no fall in the volumetric efficiency of the pumps, which made it fairly certain that there was no air in the oil. The volumetric efficiency of a high-speed pump fell very rapidly if there was the slightest amount of air in the oil. A great deal of trouble had been taken to prevent surging. A lot of the phenomenon which had been called emulsification was simply aeration due to the disturbance of the surface of the oil. It took little air to aerate a large amount of oil. If there was only a small amount in a 500-gallon tank, before long the oil was full of tiny bubbles of air. A good deal of trouble had been taken with the design from that point of view.

The chairman, in thanking the authors, said that the paper had aroused a lot of controversies, and there had been many differences of opinion in the discussion on such subjects as the advisability of having electrical equipment involved in the plant, hydraulic lock and the vexed question of cavitation or erosion.

A little while ago he had had the pleasure of holding in his hand the valve spindle shown in the diagram. He really did not know whether it was moth-eaten or eroded, but it had caused a very exciting discussion even at that time.

Bankside Power Station

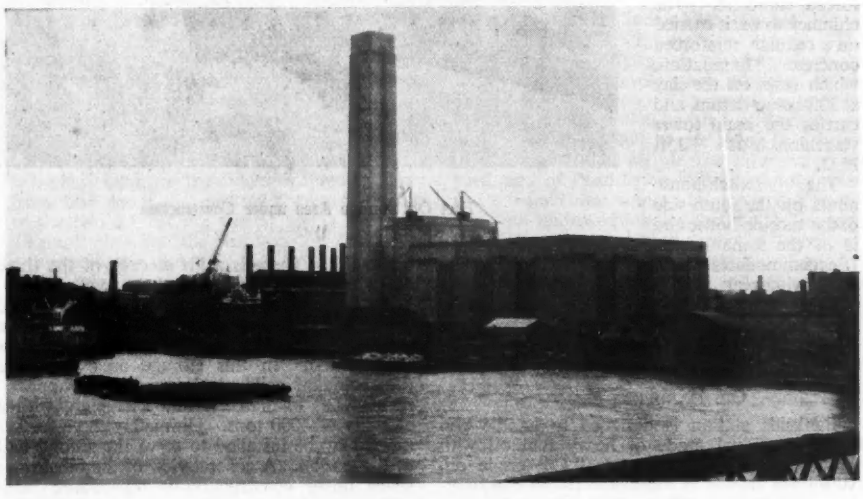
No. I

The decision to rebuild the old power station at Bankside was taken originally in 1939, *but the work was deferred for the duration of the war. When the matter was reopened at the end of the war there was strong public opposition to the building of a new power station on a site reserved for development with offices, light industries and buildings for cultural uses. A public inquiry was held and the outcome was that, because of the difficulty of finding a suitable alternative, the Government authorised the new construction. To safeguard the amenities it was stipulated that the boilers should be fired with oil instead of coal, that gas washing plant should be installed, and that the station building should be in harmony with its surroundings on the site, when fully developed.*

AS announced briefly in our issue of January 2nd, the new Bankside power station adjoining the old station on the south bank of the River Thames is now delivering a limited amount of power to the public supply system. One 60MW turbo-alternator and two 375,000 lb per hour boilers are in operation, as we saw on a recent visit to the station. By the end of the year a second generating set and two new boilers are expected to be in service, which will complete the first half of the station. Eventually, when the site is fully developed, the generating plant will consist of eight 375,000 lb per hour boilers supplying steam at 900 lb per square inch and 900 deg. Fah. to four 60MW turbo-alternators.

Bankside power station is of interest mainly because of the technical conditions that were imposed, in the interests of the amenities of the neighbourhood as envisaged in the fully developed site. It was laid down, first, that the fuel should be oil instead of coal and, secondly, that flue gas washing should be carried out. Bankside is, in fact, the first steam power station in the British public supply system to be designed specifically for oil firing. The main departure from orthodox British steam power station practice concerns the arrangements required for receiving, storing and burning the fuel oil, as described in some detail below.

An effluent flue gas treatment plant is being installed to remove sulphur oxides from the flue gases before discharging the latter to the atmosphere. Because of difficulties in obtain-



Bankside Power Station

ing cast iron casings this gas-washing plant is not likely to be ready for operation before April or May. But the generating plant has been put into service to provide additional capacity at peak hours during the winter, particularly in very severe weather. By the time the usual stages of trial and adjustment of the turbo-alternator and boilers have been completed, it is hoped that the station will be ready to begin normal operation with the gas-washing plant.

The Power Station Building

The station building, which was designed by Sir Giles Gilbert Scott, lies parallel to the river embankment and is set back so that the intervening space can be occupied by a boulevard and gardens at some future date. For the present the first half of the station, which is expected to be completed this year, presents the appearance given in the view from the river, reproduced on page 143, and the minimum interference is offered to the old station. At a later stage the old station will be scrapped and the new station completed by the addition of its second half in the form of a mirror image of the first, with the central chimney serving the whole station.

The power station building is a steel-framed structure with brick walls and a reinforced concrete roof, fitted with glass and concrete lantern lights, the dimensions of the main building being 545ft by 240ft wide. The roof span of the boiler-house is 103ft and that of the turbine-house is 76ft, and there is no separating wall. Access is provided to a central loading bay. Measured from ground level the height of the boiler and turbine-house roof is 90ft and that of the centrally situated chimney tower is 300ft.

The conditions governing the design of the foundations are typical of those on many London sites, the strata consisting of 10ft to 15ft of made ground and soft clay at the surface, 20ft to 30ft of water-bearing ballast and London blue clay beneath. For heavy loads the clay provides the only reliable foundation and all the main foundations are carried down to the clay, mostly in sheet piled and timbered trenches. The ground water level in the ballast is about 3ft below datum.

From north to south the building accommodates the boiler-house, turbine-house and switch-house, each of which has a basement at a level of −9·5ft N.D. and ground floor at 18·5ft N.D. The basement retaining wall is of mass concrete and was built in a steel sheet piled trench. Mass concrete strips founded on clay form the main stanchion and boiler foundations. The turbo-alternator foundations are mass concrete piers founded on clay and built up above the basement floor level in reinforced concrete. The chimney tower is carried on a cellular reinforced concrete foundation, which rests on the clay at 30ft below datum, and carries the main tower stanchions at +15ft N.D.

The switch-house abuts on the south side of the turbine-house and is of the same height. It accommodates the control room, transformers and switchgear at eight principal floor levels between 9·5ft N.D. and 73ft N.D. A temporary wall of sheet steel supported on a steel framework is provided at the east end pending construction of the second half of the station.

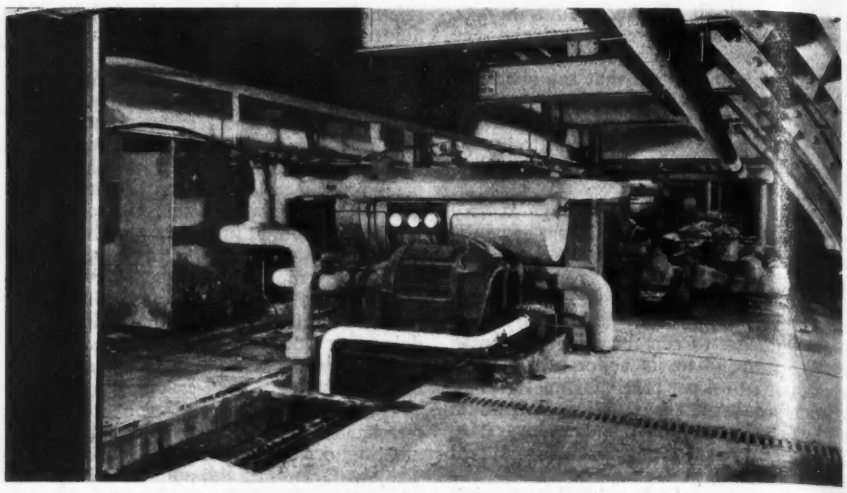
Oil Handling Plant

Bankside station is designed to handle and burn a residual grade of heavy fuel oil with properties similar to Bunker "C" grade oil. When the station is completed its oil consumption at full load will be 67 tons per hour or 850 tons per two-shift (sixteen hours) day.

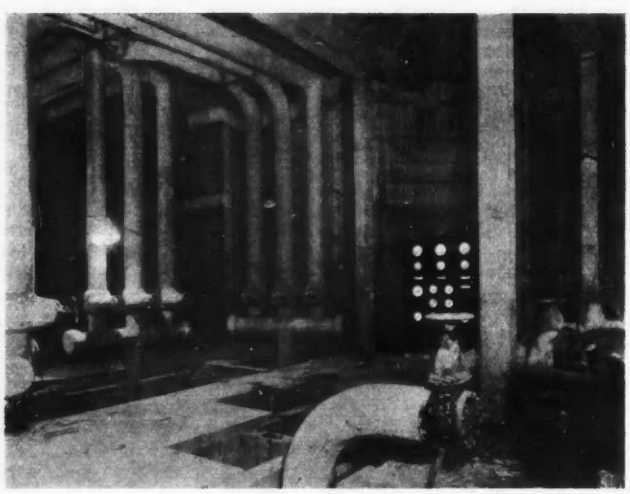
The oil has a gross calorific value of about 18,250 B.Th.U. per lb, a specific gravity of 0·98 at 60 deg. Fah., and a maximum viscosity at 100 deg. Fah. of 6500 seconds Redwood No. 1. Its normal sulphur content is between 3 and 4 per cent.

Normally the oil is delivered by self-propelled and self-discharging oil tankers from the new refinery at Shell Haven. To receive the oil tankers or barges an island jetty 293ft long was built in the river. The west end of the jetty was built of reinforced concrete in a sheet piled cofferdam measuring 100ft by 36ft, incorporating the circulating water intake structure and shaft and an 18ft diameter cast iron shaft for access purposes and oil pipes. An access tunnel 9ft 8in in diameter leads from the jetty shaft, beneath the station to the oil store, with an intermediate shaft going up to the boiler-house. This tunnel was built in free air in the clay, using concrete tunnel segments lined with 4½in brickwork. There is a lift at each of the three shafts communicating with the tunnel.

An underground oil storage area is provided south of the main station; it is enclosed by a retaining wall of circular arch and buttress construction. In this storage area there are three circular mild steel tanks, each approximately 92ft in diameter and 24ft high, with a capacity of 4000 tons. Ultimately three further tanks may be installed to serve the second half of the station. A general view of the oil storage space under construction is reproduced herewith.



Fuel Oil Heating and Pumping Sets



Fuel Oil Storage Area under Construction

Oil is discharged from the tankers via hose couplings to duplicate 10in bore oil-filling mains which lead from the jetty, through the tunnel to the storage tanks. Pumps are installed under cover on the jetty so that oil can be taken from towed barges which are not self-discharging.

Three motor-driven circulating pumps, each of 44 tons per hour capacity at 40 lb per square inch, are installed in the storage area. They pump oil through a 10in/8in ring main to the boiler-house and back to the tank; at normal tank levels, however, a gravity feed to the boiler-house is used.

Because of the high viscosity the oil has to be kept at a temperature of not less than 110 deg. Fah. for ease of handling. Steam heating coils are installed at the base of each storage tank and all pipelines are traced with one or two 1in steam lines. The jetty off-loading and boiler-house circulating pumps, together with filters, &c., are steam jacketed.

To supply the steam for oil heating a separate auxiliary system operating at 250 lb per square inch, saturated, is installed. Steam at this pressure is required for the oil heaters associated with the boilers and for tank and oil-pipe heating the steam is reduced to 50 lb per square inch. One of our illustrations shows the oil pumping and heating sets. The steam is supplied either by two high-pressure evaporators through steam coils connected to the 900 lb per square inch steam range, each having an output capacity of 18,000 lb per hour, or by two Cochran "Economic" horizontal oil-fired boilers, each with a capacity of 5000 lb per hour. All drains are conserved and led back to the evaporators or "Economic" boilers via a de-oiling and filtering plant. The station heating and domestic supplies are taken from the 250 lb per square inch system. Initially a cross connection was made to the existing station steam mains for early operation.

(To be continued)

Overside Lift.—An electrically operated overside hoist for transporting the crew to and from the ship, when lying at a quay, is to be fitted to the oil tanker "Helix," building by Swan, Hunter and Wigham Richardson, Ltd., for the Anglo-Saxon Petroleum Company, Ltd. This patented lift, which will transport six persons or 10 cwt of stores and is being developed by Clarke Chapman and Co., Ltd., under the guidance of Mr. John Lamb, is not affected by the list or trim of the ship and is not independent upon guide rails.

Development of Milking Machines.—At a meeting of the Institution of British Agricultural Engineers, held in London on Wednesday last, January 21st, a paper entitled "The Design and Development of Milking Machines" was presented by Mr. H. S. Hall. He said that virtually all the basic principles of the modern milking machine had been suggested, and mostly established, by 1903. During the succeeding thirty-five years development of machine design had been entirely commercial, with little guidance from scientific research and without any clear understanding of the factors involved. In the years 1950 and 1951, Mr. Hall stated, manufacture of milking machinery for the home market was over 27,500 complete plants, but the increase of installations between January, 1950, and January, 1952, was only just over 12,000. Production last year, therefore, he suggested had necessarily declined.

Electronic Control of a Constant-Weight Feeder

AN interesting application of electronics to automatic control of the flow of materials is embodied in the installation at the Heysham Works of Imperial Chemical Industries, Ltd., of two constant-weight feeder equipments. The machines were built by Richard Simon & Sons, Nottingham, and are controlled by electronic gear supplied by the General Electric Company, Ltd. Each equipment provides a closely-regulated flow of approximately 10 tons per hour of

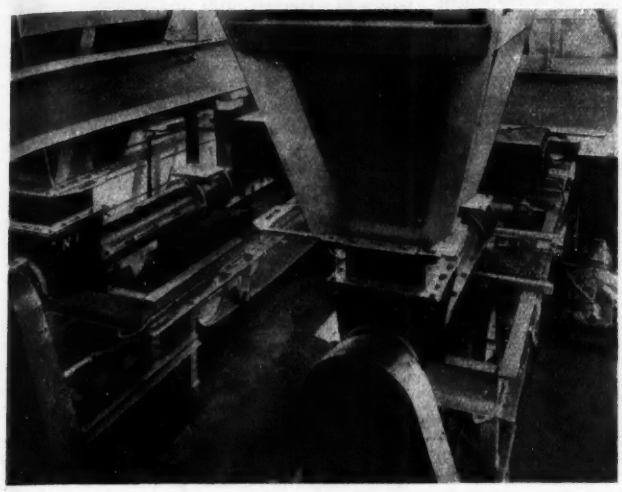


Fig. 1—Constant Weight Feeder Equipments

powdered limestone, which is used in a continuous chemical process. Any desired rate of flow over a range of 3½/1 in weight can be selected by means of a calibrated control knob, and this flow is then automatically maintained by the equipment.

A general view of one of the machines is reproduced in Fig. 1 and the method of operation is shown in Fig. 2. Powdered limestone from the preceding stage of the plant is fed into a hopper and is loaded on to a conveyor belt by a motor-driven screw in the base of the

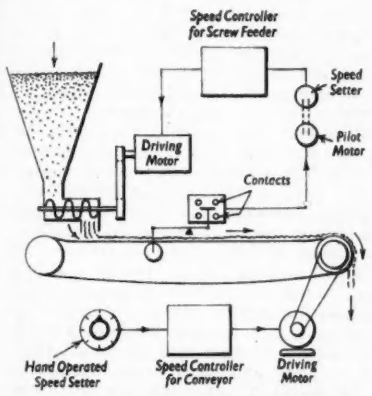


Fig. 2—Diagram of Constant Weight Feeder

hopper. The centre portion of the loaded belt passes over a roller which is linked mechanically to a sensitive weighing mechanism housed in a container above the belt, and two sets of contacts mounted on the weighing mechanism are employed to give signals to the electronic control gear when the loaded belt is too heavy or too light. The screw speed is then automatically adjusted until the balance of the weighing machine is restored, so that a constant flow of limestone is maintained for a constant speed of the conveyor belt.

As the machines are controlled by weight their operation is independent of any changes in the bulk density or in the ability of the material to flow. Thus, if there is a partial blockage in the feed inlet the weighing machine will promptly detect the reduction in the feed rate and automatically apply the necessary correction to the feed control unit (in this case the pilot motor and speed setter unit), as described below. Similarly, if there is a change in the density or consistency of the product the weighing unit will cause the feed control unit to operate and adjust the flow to the desired preset rate.

The adjustment is effected by a simple automatic two-rate correction control. If a large change takes place in the bulk density of the material a continuous correction is applied to the feed control unit until the feed rate is correct. The weighing unit will then apply corrections in small increments only, thus preventing hunting. Pilot lamps are incorporated to show the operator which correction is being applied to the feed rate.

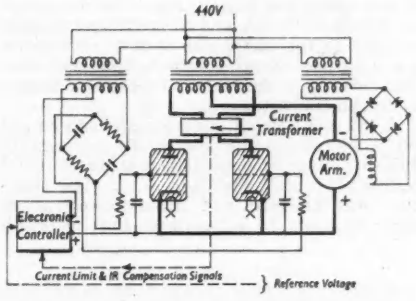
The setting of these feeders for a given throughput is simple. After placing the required weights on the weighing beam the operator presets the flow rate by setting the band conveyor speed controller until the required speed is shown on the tachometer dial. A conversion scale is provided to indicate the rate of flow in tons per hour. The machine is fitted with a cut-off switch which sounds an alarm when there is no material above the feed inlet. The feeders also record the amount of material which has been delivered.

All the control gear, including the electronic apparatus for each feeder equipment, is housed in a ventilated cubicle of sheet steel construction and, to keep out dust, the control cubicles for both equipments are mounted side by side in a pressurised control room.

The equipment operates from a 440V, three-phase, 50 c/s supply and is provided with a 3 h.p. variable-speed d.c. motor for driving the screw and a similar motor rated at 1½ h.p. for driving the conveyor belt. Both machines are separately excited, the d.c. supplies for the field circuits being obtained from metal rectifiers and the supplies for the armatures from thyratron rectifiers. A three-phase bank of thyratrons is used for the supply of the screw motor and a two-phase bank for the conveyor motor ; apart from this detail the electronic control circuits of the two motors are similar and a simplified diagram showing the method of control is reproduced in Fig. 3.

The principle of operation is that an adjustable "speed setting" reference voltage is provided for the control of each motor. The speed setting of the band conveyor is adjusted manually as previously described, and in the case of the screw feed motor a pilot motor is used to vary the speed setting in accordance with the signals from the contacts on the sensitive weighing mechanism. In each case the reference voltage is compared with the voltage across the armature of the motor and the difference voltage is then amplified and is supplied to the control grids of the thyratron rectifier. The output voltage of the rectifier, i.e. the voltage applied to the armature, is thereby varied to match the voltage selected by the speed setter.

To protect the thyratrons from overloads a limiting circuit is included which prevents the armature current from exceeding a predetermined value. If the motor is stalled the current will remain at the limiting value for 30 seconds, after which a thermal overload trip will open the armature contactor.



The reference voltage is manually set for the conveyor motor and is automatic for the screw motor.

Fig. 3—Simplified Diagram of Control Circuit

The fall in motor speed as the mechanical load is increased is corrected by a compensating circuit which increases the voltage applied to the armature in proportion to the increase in armature current.

Short Notices

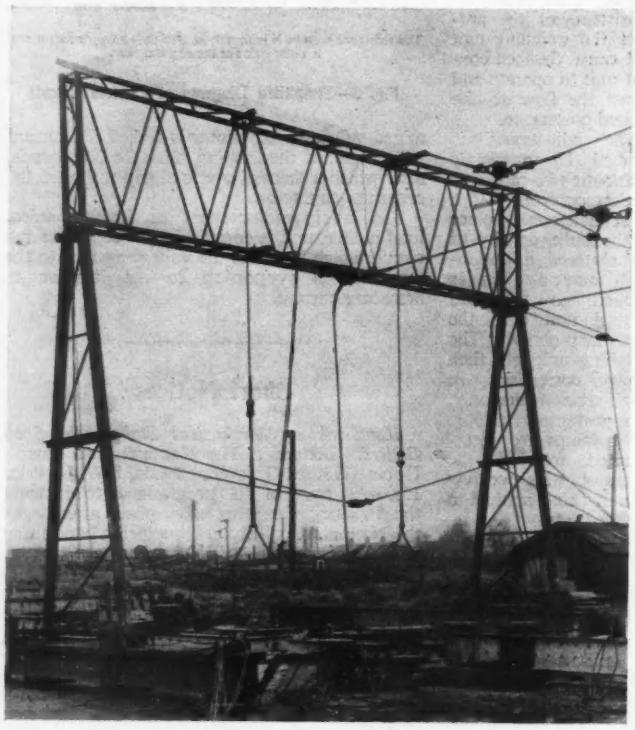
Handbook on Mechanical Stokers for Shell Boilers. London : The National Coal Board, Hobart House, Grosvenor Place, S.W.1. Price 15s.—As part of its programme to increase the efficiency of existing boiler plants at collieries the National Coal Board is replacing hand firing wherever possible with mechanical stokers. Training courses for existing staff at the collieries have been arranged to show them how to obtain the best efficiency with the new equipment, and this book is intended to serve as a guide in these courses. The handbook deals with the commercial classification of coals ; the burning of coal ; system of firing ; supply of air for combustion ; grates ; coking and sprinkler stokers ; chain and travelling grate stokers, and underfeed stokers. The information is given in a clear, concise manner and is well illustrated by numerous diagrams and photographs to assist the reader in further understanding the construction, operation, care and maintenance of mechanical stokers of many kinds.

High Paddington. By Sergie Kadleigh. London : Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.I. Price 7s. 6d.—This work contains forty pages of description and illustrations of a development proposed by the author in Paddington. The project is intended for submission to the housing authorities. It is for a town of 8000 people rising to a height of 400ft and sited astride the extensive goods yard area of Paddington railway station, where trains would run under the town unhindered and with improved loading facilities. The town first rises on a broad base, termed a "podium," in storeys of commercial properties. Springing from the roof of the podium and set around a great central court more than 570ft across at its widest points, are three tall blocks of dwellings over 300ft high which are crowned with two primary schools, hotel, hospital and a church. Around the base of the dwellings and surrounding the court is a main concourse, which contains bowling green, tennis courts and children's playground and gardens. Here, too, are the town's shops, restaurant, post office, police station, public houses and other facilities for the benefit of the townspeople.

Tubular Steel Structures for Railway Electrification

In a paper read recently before the Institution of Electrical Engineers* reference was made to the possible use of welded tubular structures for supporting the overhead line equipment in order to effect economies. This investigation, it was stated, was being made at the instigation of British Railways, and the paper particularly referred to the 1500V d.c. system installed on the Liverpool Street-Shenfield Line and now being erected on the Manchester-Sheffield section of British Railways.

A test was recently arranged and carried out on a prototype structure in the presence of British Railways representatives at the Hereford testing plant of Painter Bros., Ltd. This structure was designed and manufactured at its Newport works by Tubewrights, Ltd., to British Railways specification, so as to afford a comparison with a corresponding structure in ordinary standard steel sections tested in 1938 under the same conditions. We are informed that the tests were completely successful in that not only did the structure withstand 2·5 times the design loads but also an additional load applied to one mast, for which provision had not been made in the design.



Tubular Steel Structures on Test Bed

The illustration we reproduce on this page shows the anchor structure spanning two tracks mounted on the test bed. The overhead equipment carried by such a structure would be a compound catenary construction consisting of a main copper catenary 37/0·104in carrying a 19/0·112in copper auxiliary catenary, which in turn supports the 0·3 square inch solid grooved cadmium copper contact wire. This type of structure is designed to take the out of balance oads in a direction parallel with the tracks of one broken equipment. At the same time it has to withstand the transverse loads due to a 50 m.p.h. wind on the wires with the supporting catenary cables covered with ½in radial thickness of ice. The tensions in the wires are those produced by these same conditions, namely, a 50 m.p.h. wind at 20 deg. Fah. on ice-loaded wires, and are considerable, being 5270 lb in the main catenary, 4650 lb in the contact wire and 2557 lb in the auxiliary catenary.

The bridge member of the structure consists of two 3½in by 5 S.W.G. tubes forming the top boom and two 4in by 5 S.W.G. tubes for the bottom boom. These tubes are 1ft 3in apart and are welded together by diagonal tubular bracing consisting of 1 ⅜in by 8 S.W.G. tubing. The vertical depth of the bridge is 6ft 6in, the top and bottom booms being welded together by diagonal tube bracing, to form a strong and rigid box girder. End posts of 4½in by ½in tube are provided with flanges which are bolted to the tops of the masts.

The masts which have to take the direct compression and tension produced by the longitudinal loads are also subjected to bending produced by the transverse wind loads on the wires and on the structure itself. They consist of two tubes 6⅝in diameter by 5 S.W.G., 1ft 3in apart at the top and 6ft 6in apart at the base. They are 18ft 6in high and are connected by a common flange-plate at the top, to which the bridge member is bolted by eight 1½in diameter bolts. At the bottom each tube is provided with a fabricated foot which is bolted down to a concrete foundation by means of clamping bars embracing pairs of four bolts per leg. The masts are welded together to form an " A "-frame by 1 ⅜in by 8 S.W.G. tubular bracing.

For the tests the structure was mounted on two heavy R.S.J.s, which were themselves bolted down to the testing plant foundations. Loads were applied by means of scale pans and weights attached to cables and pulley-blocks for the smaller transverse and vertical loads, and through 10-ton dynamometers for the heavy loads. Loads were applied in stages up to 1·5 times working load, at which point all loads were released and any small permanent set recorded. This amounted to 1½in at the top of the masts in the transverse direction, there being none at all longitudinally.

Loads were then reapplied up to 2·5 times the working load, which the structure withstood without failure. An additional load of 2400 lb was then applied to one mast, representing a terminated earth wire, and the structure withstood 2·5 times this load without failing. Upon all the longitudinal loads then being increased the bridge top and bottom booms quickly failed by buckling at the point of load application. No failures occurred in any of the welds—a point of some importance since the use of all-welded tubular construction involving welds in tension is new to British overhead line construction.

The weight of the structure was approximately 1·7 tons as against 2·95 tons for a normal lattice structure and the makers point out that although the price per ton is higher than for bolted and riveted construction the saving in weight can effect a saving in cost of 25 to 30 per cent. This saving in cost, it is stated, becomes more marked in the case of large structures required in sidings and station areas where a considerable number of tracks have to be spanned and equipped.

Tubular construction has other advantages in that the structures offer less resistance to wind, painting of the round surfaces is easy and there is a reduced tendency to collect soot and dirt from steam locomotives.

We understand that as a result of this test two or three tubular structures are to be installed for trial purposes on the Manchester-Sheffield electrification.

* "Economic Aspects of Overhead Equipment for D.C. Railway Electrification" by O. J. Crompton and G. A. Wallace.

Temporary Relaxation to the I.E.E. Wiring Regulations

In response to an approach made by the Ministry of Works, with a view to economising in the use of copper for cables, the Institution of Electrical Engineers has reviewed the position as affected by the twelfth edition of the "Regulations for the Electrical Equipment of Buildings." As a result of this review it was concluded that for larger cables the problem of current rating was closely bound up with that of voltage drop, and it was considered undesirable to authorise any general increase in the maximum voltage drop permitted under Regulation 304 of the twelfth edition. It appeared, however, that some saving of copper might be possible in the range of small cables, the ratings of which had not been dictated by thermal considerations alone, since questions of mechanical strength, particularly at terminals, entered into the determination of conductor size.

The council of the Institution has therefore decided to issue as a temporary relaxation to the twelfth edition (and the abridged Regulations) a revised Table 5 incorporating the higher current ratings for cables with conductors up to 7/0·029in which had been adopted in 1942, but with the limits of voltage drop reduced to agree with those shown in the twelfth edition.

It is understood that the Electrical Research Association and Cable Makers' Association are conducting further tests on the thermal rating of cables and that the results will need to be checked with cables manufactured to revised British Standards for Rubber and P.V.C. Cables now in preparation by the British Standards Institution. It has been agreed, therefore, to review the tables of the twelfth edition in the light of the results of this research, as part of the work lately authorised for the preparation of the thirteenth edition of the Regulations.

A copy of the Temporary Relaxation to the Regulations (and Abridged Regulations) may be obtained free of charge from the Secretary of the Institution, Savoy Place, London, W.C.2, on receipt of an addressed envelope bearing a 1½d. stamp. Copies of the twelfth edition of the Regulations may be obtained from the Secretary of the Institution, price 5s. (paper cover) or 7s. 6d. (cloth bound), including postage. Copies of the Abridged Regulations may be similarly obtained, bound in limp cloth, price 2s. 6d., including postage.

The National Packaging Exhibition at Olympia

On Tuesday last, January 20th, the third National Packaging Exhibition was opened at Olympia, London,* by the Minister of Food, Major Gwilym Lloyd George. At this exhibition, which will remain open until Friday, January 30th, more than 150 firms are showing their products, machines and the services they have to offer for this important side of industry. During the past few years packaging in this country has developed to a considerable extent as manufacturers have increasingly recognised that an attractive package can have a considerable influence on sales, and that efficient packing with the correct materials not only reduces risks of damage in transit, but can protect and preserve goods under adverse storage conditions. As a result of this appreciation on the part of manufacturers, a great impetus has been given to the development of new and improved materials and methods, and many firms have specialised in the design of machinery for wrapping and packing goods economically with a minimum of labour. It is only at an exhibition of the kind now at Olympia that the various trades can fully appreciate the plant and services which are at their disposal. In addition to the machines specially designed for rapidly and hygienically weighing, wrapping and sealing all classes of foodstuffs, chemicals, liquids, &c., there is exhibited an impressive range of wrapping materials from papers to the latest synthetic products, as well as examples of cartons, tins, bags, &c., designed with a view to sales appeal, combined with adequate protection.

A Hydraulic Press and Drawbench Installation in America

(By our American Correspondent)

As part of its post-war expansion programme, the Babcock and Wilcox company has built and installed at its boiler works at Barberton, Ohio, the largest press for the forming of boiler drum plate in America and a drawbench which facilitates the production of heavy-walled hollow seamless sections by piercing and drawing instead of by forging and boring out an ingot. The 6000-ton press is capable of bending boiler plate sections up to 42ft long, and the 1100-ton drawbench can produce hollow sections up to 35in outside diameter and 4½in wall thickness.

THE vertical press and the horizontal drawbench which have been installed at the Barberton works of the Babcock and Wilcox Company will serve to accelerate the fabrication of steam generating equipment and will help to reduce boiler manufacturing costs. The press will be used to bend heavy steel plate for boiler drums and will also be used to pierce ingots, which will then be transferred to the drawbench to be formed into hollow sections for boiler headers and other special parts. Considerable savings will be made possible because the press is capable of handling 42ft long plate sections. As it takes approximately as long to bend a 10ft length as a 42ft length, the savings obtainable in forming a boiler drum 84ft long from two 42ft sections, as opposed to many shorter sections, are evident. Furthermore, with 42ft sections, only three circumferential welds are necessary to form a complete drum, as against the ten welds necessary when 10ft sections are used. This technique results in substantial economies not only in fabrication but also in the subsequent X-ray inspection of the welds.

The horizontal drawbench will greatly facilitate the manufacture of heavy-walled, seamless hollow sections used in making boiler headers and connecting steam lines. Until now, such hollow sections could be made in the United States only by the costly and time-consuming process of forging large solid ingots and then boring out their centres. With the new drawbench equipment, heated ingots can be removed from the furnace, pierced by the hydraulic press, and drawn through a series of ring dies over a mandrel to form a rough hollow forging in a few minutes.

Vertical Press

The vertical hydraulic press, which is shown diagrammatically in Fig. 1, has a normal operating capacity of 6000 tons and an intensified capacity of 8000 tons. Its hydraulic system operates at a pressure of 3000 lb per square inch. It has a daylight opening of 20ft and an operating stroke of 9ft 6in. The three 45in diameter main cylinders and the bottom, movable, and top platens are fabricated. The platens weigh 120 tons, 180 tons and 105 tons, respectively. The rams of the press are cast iron and are 43½in diameter. The columns are 26in diameter and 52ft long and are located on 16ft centres across the face and on 14ft centres across the side of the press. There are two 12in diameter balancing cylinders and two 12in diameter pull-back cylinders. Situated on the press centre and in the pit below the bottom platen is a 450-ton ram, 22in diameter, having a 4ft 6in stroke, which has been provided for the piercing of manholes in drum heads. This ram is fitted with two return cylinders. The matrix used for piercing is fitted with an 11¼in diameter ejector ram having a 8ft 6in stroke.

Operation of the press can be arranged with high pressure applied (*a*) only to the centre cylinder; (*b*) only to the two outside cylinders; or (*c*) to all three cylinders, so that forces of approximately 1900 tons, 4000 tons and 6000 tons are available on the down-stroke. The down-stroke travel protection is obtained with a limiting valve which is automatically opened at the 9ft 6in level and which releases the high pressure at this position. To provide greater ease of operation, the main hydraulic valve is controlled by an oil cylinder fitted with a servo-mechanism. Interlocks have been provided on all separate functions to prevent accidental damage and maintenance has been simplified by using outside packing on all main cylinders.

When functioning as a piercing press, the heated billet is loaded into the matrix and the stripping plate installed while the matrix is positioned on a shifting table situated 14ft from the centre of the press (Figs. 1 and 3). The loaded matrix is then moved into the working position by the shifting table. This table is moved by a ram having a 14ft stroke, which is actuated by a 9in bore cylinder in one direction and two 6½in bore cylinders in the opposite direction. The weight of the maximum size billet that can be handled is 12 tons. Subsequent to the press piercing cycle, the shifting table returns the matrix to its former position, where the ejection cylinder functions to unload the workpiece. Actuation of the shifting table, the ejection cylinder and the 450-ton pit ram is by push-button control.

When the press is utilised for forming drum-shell plates to a predetermined radius, the piercing matrix is moved by the shifting table to a position at the rear of the work area of the press. This leaves an unobstructed space between the press columns for the entry of a hydraulically operated plate manipulator, which moves the workpiece from its loading position to its work position under the moving platen, as shown in Fig. 2. This plate manipulator, which comprises the 42ft long lower press bending beam, also forms the carriage required to effect the cross-travel of the shell plates through the press. It houses a

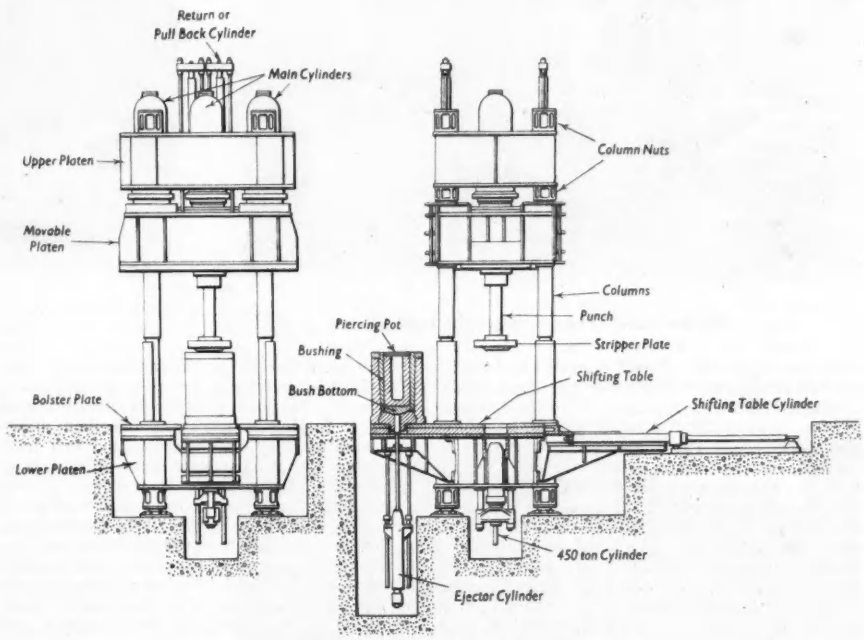


Fig. 1—Diagram of Vertical Press

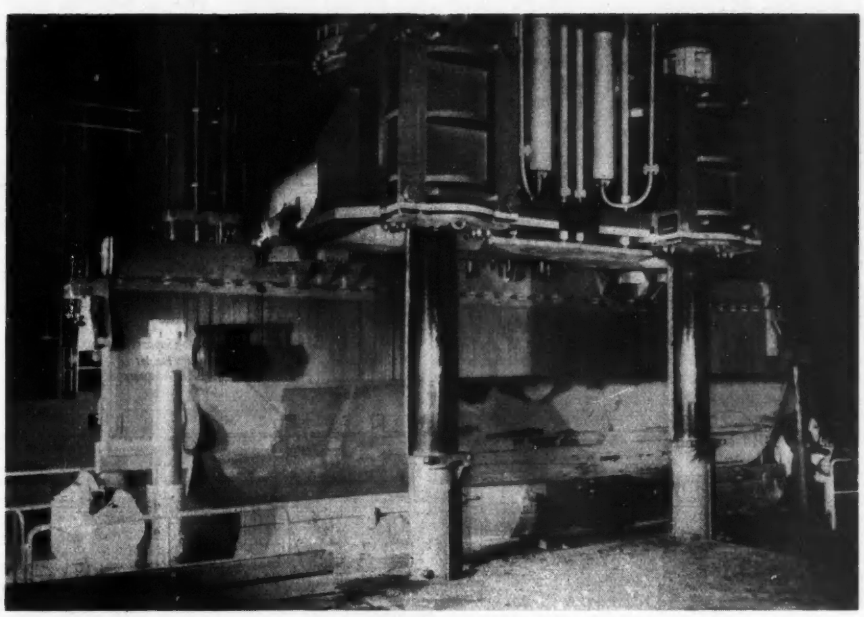


Fig. 2—Vertical Press Arranged for Plate Bending

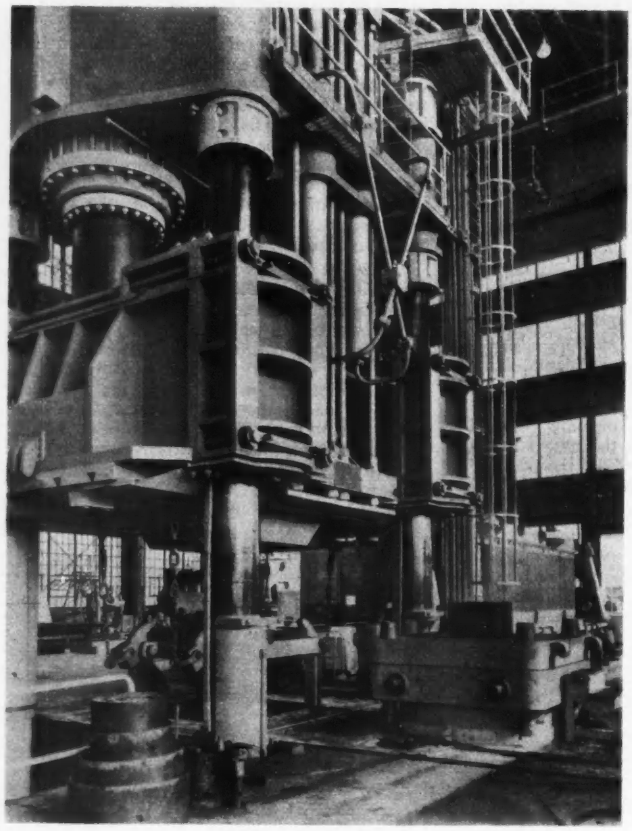


Fig. 3—Vertical Press Arranged for Ingot Piercing

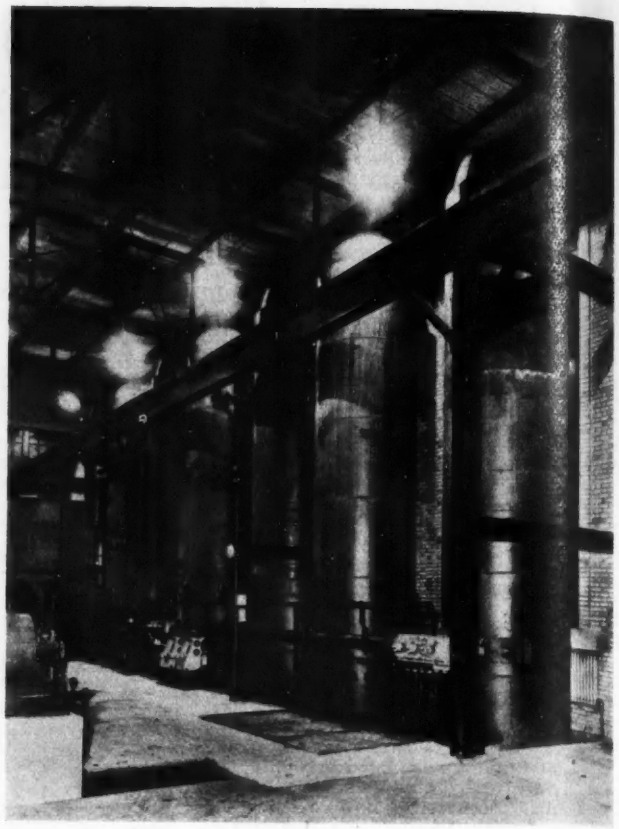


Fig. 4—Accumulator Plant

16in bore hydraulic cylinder provided to actuate the 52ft stroke ram which moves the manipulator carriage. Mounted on either side of the carriage are four hydraulically operated rams for handling the workpiece. These manipulators comprise vertical, trunnion-mounted cylinders, which actuate rams each having a stroke of 6ft 10in and a handling capacity of 30 tons. The cylinders for each unit are mounted on a carriage that moves in contact with the side of the lower press bending beam and also with rails mounted in the press foundation. The carriages are adjustable longitudinally so that they can be spaced from 8ft. to 42ft. apart to handle plates of varying lengths. Angular tilt of the manipulators of approximately 20 deg. from the vertical to the edge of the beam is obtained with the aid of cross cylinders also mounted on the carriage.

All motions in connection with the manipulator are hydraulically controlled. Movement is instituted by electric push buttons, which energise solenoids which in turn actuate air pilots on the hydraulic pressure lines. There are six push-button control panels, arranged so that one operator can position the workpiece on the lower bending beam, move it to the work position in the press, and also start the forming cycle on the press.

The procedure for forming plates is to cold press in their entirety plates up to about 2¼in in thickness. Heavier plates are rough-formed while at forging temperature and then finish-formed after they have cooled to room temperature. The same set of dies are used for both cold and hot forming. Over-travel on the manipulator carriage permits positioning of workpieces within the limits of the top platen in such a manner that heavy and unequal loading of the overhung portion of the 42ft long bending beam can be avoided. A tilt of the movable platen of $\frac{11}{16}$in from the horizontal plane, measured at the outer edge of the platen, has been provided to compensate for unequal loading of the bending beam when forming plate. This is absorbed by spherical bearings mounted in the column guide bushings in the platen. When not required, this tilt is eliminated by hydraulically operated wedges which lock the platen in a true horizontal plane. Arrangements have been made for the rams to take, on spherical washers, the slight amount of side thrust that may occur.

In addition to the piercing of ingots and the forming of heavy drum plate, the vertical press can be converted for use in the forming of heavy pressure vessel heads, warped sections and other general-purpose press work. Special fabrication operations, such as upsetting, reducing, expanding and cold drawing, can also be performed on this equipment when required.

Horizontal Drawbench

The horizontal 1100-ton drawbench, which is shown diagrammatically in Fig. 5, is utilised in the forming of hollow forgings. Capacities of either 550 tons or 1100 tons can be selected for its forward stroke, which is 30ft in length, while its return stroke capacity is 550 tons. The unit has an overall length of 114ft and a 32in main cylinder bore. The drawbench columns are 16in in diameter and have an overall length of 84ft. The die bed is 31ft 6in long, die-holder locations being provided along 28ft of

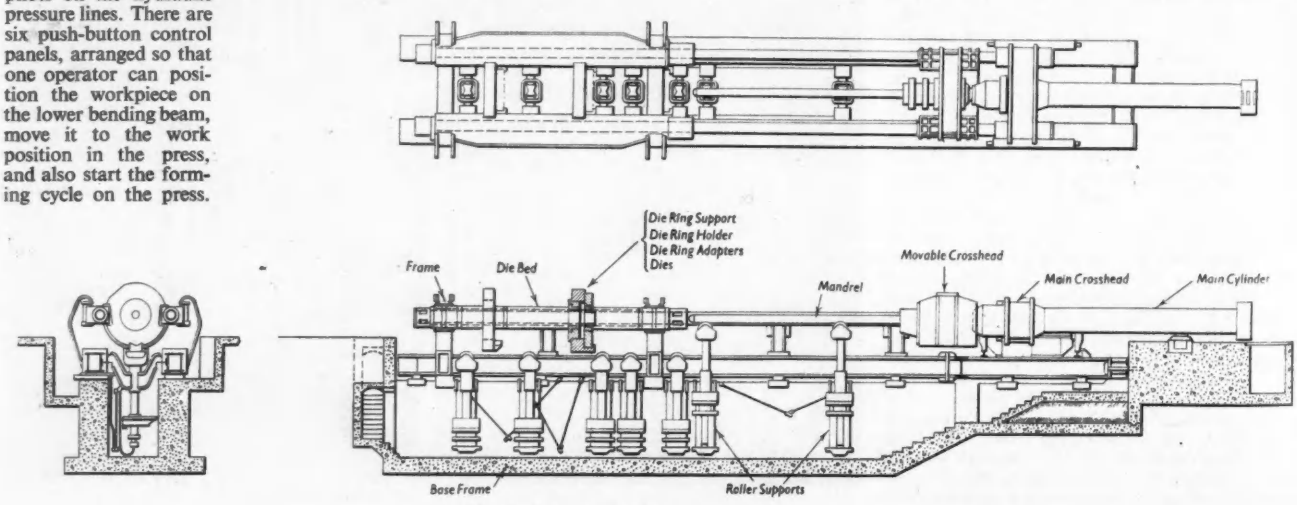


Fig. 5—Diagram of Horizontal Drawbench

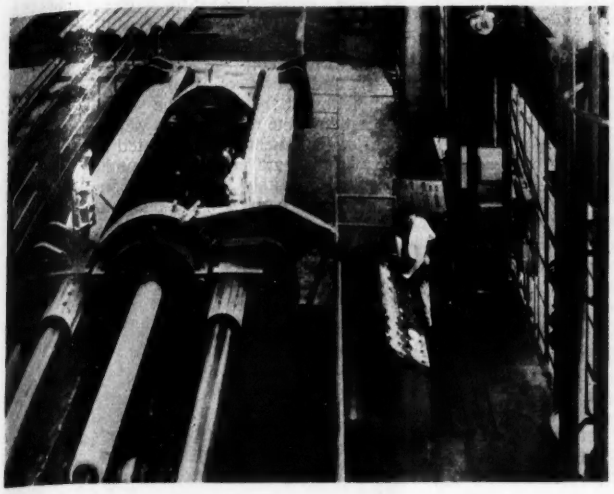


Fig. 6—Horizontal Drawbench in Operation

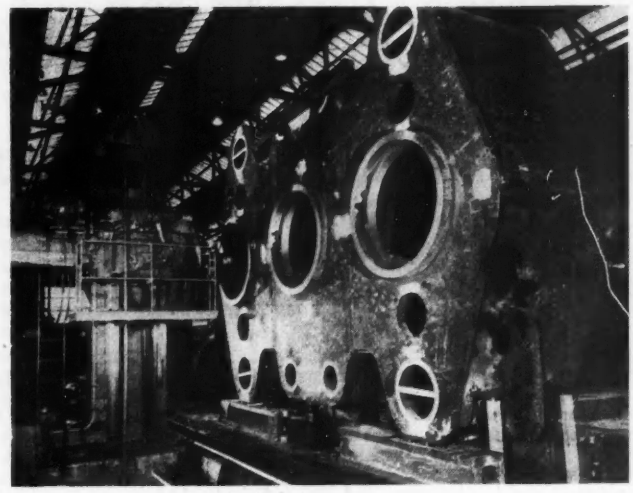


Fig. 7—Machining of Press Platen

its length. The unit is equipped with a swivel design die holder and with seven roller supports. The latter serve to position and support the mandrel and the workpiece and are hydraulically operated over a 25in vertical range. The roller supports are push-button operated and can be shifted lengthwise along the draw bench as required.

The hydro-pneumatic pressure system, installed for operating both the press and the drawbench, is powered by three triple-piston, single-stage pumps, each geared to a 500 h.p., 2300V synchronous motor. Each pump has a delivery rate of 234 U.S. gallons per minute at a pressure of 3000 lb per square inch. The large high-pressure storage capacity required for the installation is provided by an accumulator plant comprising two water and five air cylinders, which are illustrated in Fig. 4. A lubricant is used in the water to prevent oxidation of the working parts. Automatic operation of the pumps is accomplished with a high and low-pressure level control. A sequencing device permits alternate operation of the three pumps.

In making a hollow forging, the vertical press is used initially to pierce a heated ingot longitudinally. The hollow ingot, or bloom, is then transferred to the horizontal drawbench and is fitted over a mandrel selected according to the desired inside dimensions of the forging. The hot bloom (Fig. 6) is now forced through a series of ring dies by the head of the mandrel, reducing the outside diameter and increasing its length until the final size of the vessel has been obtained. Ingots of non-circular cross-sections, such as gothics, hexagons, octagons and squares, can be shaped on the equipment. Similarly, non-circular mandrels and dies can be employed on the horizontal drawbench to produce cross-sections such as squares, rectangles, "D" shapes and ovals.

The equipment will produce seamless hollow forgings from a minimum inside diameter of 8in and a wall thickness of ¾in up to a maximum inside diameter of 26in and a wall thickness of 4½in. The 12-ton maximum weight of the cropped ingot which the equipment can handle controls the maximum final length of the forging which may range from 14ft for heavy wall thickness and large diameters, up to 22ft for lighter wall forgings. As the ring die tooling for the drawbench can be changed quickly, it is possible to produce even only one or two lengths of a particular size or of a particular material specification at comparatively little unit cost per forging. Both alloy and carbon steel forgings have been produced successfully on the equipment.

Fabrication

The decision to proceed with this installation was made several months prior to the outbreak of the war in Korea and the material required was ordered at that time. Since the major components involved were too large to be transported by rail, it was decided to build them in the company's own shops. A special building for the new press and drawbench was constructed on the works site. Planned specifically for this extension of facilities, it is 105ft wide, 275ft long and 92ft high. Concrete supports for the press were sunk into a 26ft foundation pit and on this foundation were placed the four 26in diameter supporting columns.

The largest of the three press platens weighs 180 tons. It is believed to be the largest fabricated steel press platen ever made and required precise control of all operations during fabrication. Preheating units were applied at various points to keep the platens at an even temperature to reduce possible cracking during welding. All of the weldments were completely stress-relieved prior to machining. For machining, each platen was lifted and set on its edge by a crane in front of an 8in spindle horizontal boring mill, as shown in Fig. 7. The completed platens were transported to the new press building on a short works railway line constructed specially to carry this heavy equipment. Approximately 400ft of temporary tracks were laid for the operation.

A 90-ton overhead travelling crane has been provided to lift and move the heavy pieces which are fabricated on the press and the drawbench. To heat the heavy drum plate as well as the forging ingots, a special furnace has been built, which has 14ft by 50ft by 7ft inside dimensions. An additional heating furnace is now under construction and, to ensure an adequate supply of the special analysis ingots required for this operation, a self-contained ingot melting shop is also being constructed.

Both the vertical press and the horizontal drawbench were designed by Hydropress, Incorporated, of New York City.

Redruth Home Service Transmitter.—To improve reception of the West of England Home Service around Redruth, Cornwall, the B.B.C. proposes to add a third transmitter to its present station at Redruth, which already broadcasts the Light and Third Programmes. The new transmitter will be of 2kW power and will share the wavelength of 206m (1457kc/s) which is already used by other stations radiating the West of England Home Service. The area within which Home Service reception will be improved will include the towns of Redruth and Camborne and the rural districts immediately to the north of Redruth, extending to the coast. It is hoped that the transmitter may be brought into service this year.

Tractor for Railway Goods Depots

We reproduce on this page a photograph of a new battery-operated drag tractor which has been designed and built by Scott Electric Vehicles, Ltd., in co-operation with British Railways, and is now in service at the Lawley Street Depot, Birmingham. We are informed that these tractors will eventually replace the horses now used for hauling drays at important railway goods depots in all parts of the country.

The tractor is designed to haul a payload of 1 ton and in service it is simply backed under the front of the dray to be moved and its rear platform is then elevated to lift the front axle and raise the wheels about 6in off the ground. The dray can then be towed and manœuvred into the required position by the tractor driver. With a dray in tow the tractor has a turning circle of about 24ft. The driver's seat is positioned at a height which enables him to walk on or off the dray without jumping down.

Electric Tractor for Railway Goods Depots

The controls simply consist of a steering wheel and brake, a three-step controller operating through a "travel" resistance wound on six formers and a push-button elevating control for the platform. The 2 h.p. motor which drives the split rim front wheel through a chain propels the tractor at a maximum speed of 4 m.p.h., loaded or unloaded. The rear platform is raised hydraulically by a hump which is coupled to the shaft of a separate elevating motor. Power for both motors is supplied from a 24V "Kathanode" traction battery, with a capacity of 184Ah at ten-hour rating. Solid 10in by 4in tyres are fitted on the rear wheels and an 18in by 7in pneumatic tyre on the front driving wheel.

The Metropolitan Water Board's Works in 1952

A brief review is given below of the progress made during 1952 *on the various new works of the Metropolitan Water Board. The provision of adequate storage reservoirs for the maintenance of the supply in times of drought and the construction of sufficient filtration plant to ensure the purity of supply, remained the two main problems confronting the Board, as in previous years, owing to the continued restrictions on capital works, and the Board was not able to resume work on the construction of the storage reservoir at Walton or commence work on the proposed new reservoirs at Wraysbury and Datchet during the year.*

THE filtration works and pumping station at Ashford Common remained the major work of the Metropolitan Water Board under construction in 1952. The filtration works will provide a reliable supply of 90 m.g.d. of filtered water, and the pumping station will contain high-lift pumps for pumping this water into supply in the London area, and also sufficient low-lift pumps for pumping out from the Queen Mary reservoir 200 m.g.d. of stored water for the supply of Ashford Common or other filtration works, when the level of the reservoir is so low that the gravitational supply is insufficient.

The filtration works when completed will consist of two circular aeration basins, each 90ft in diameter ; a micro straining plant containing twenty-four rotary straining units, each 10ft in diameter, and of 10ft effective length ; thirty-two slow sand filters, each having an area of about ¾ acre, and two contact and balancing tanks, each having a capacity of 5·8 m.g. The water from the slow sand filters will be lifted into the two contact tanks by two subsidiary low-lift pumping stations.

The whole of the civil engineering work, with the exception of the raw water tunnel from Queen Mary reservoir, is being carried out by John Mowlem and Co., Ltd. The two aeration basins and the thirty-two slow sand filters were completed during the year, and the two contact and balancing tanks were finished except for the roof of the west tank, which is now under construction. The placing of the earth filling and embankments round the filters and contact tanks was also well advanced. The micro screening units are being manufactured by Glenfield and Kennedy, Ltd., and the construction of the building to house the screens will be commenced shortly.

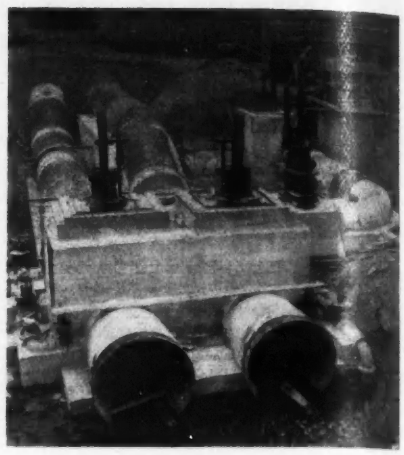
The accompanying illustration of the main pumping station shows the good progress that was made in its construction during 1952, and the second illustration shows the delivery mains from the high-lift end of the pump-house. The external brick and stone work was completed for the pump-house and generator house, the main roofs were concreted and asphalted, and the internal floors laid ; construction of the foundation blocks for the pumping and generating machinery is now in progress. The travelling electric cranes were erected during the year, and the high-lift vertical-spindle pumps are being installed by the Harland Engineering Company, Ltd.

The 96in internal diameter concrete-lined tunnel, which will bring raw water from the Queen Mary reservoir to the new works was completed during the year by Kinnear Moodie and Co., Ltd. The tunnel, which is about 630 yards long, was driven through the London clay at a depth of about 90ft below ground level. Experimental work is now in progress to determine the pressure which will develop between the clay and the tunnel lining under varying conditions.

Hampton.—The capacity of this works has been increased from about 55 to 120 m.g.d. during the past few years, and the balance of the remodelling scheme is now in progress or about to be commenced. Apart from a small amount of finishing work, construction of the new raw water pumping station at Sunnyside was completed in 1952, and the pumping plant installed. The pumping connections are now being laid by J. L. Eve Construction Company, Ltd. The building of a new chlorinating house was completed, and the installation of the chemical treatment plant is in progress. The construction of a reinforced concrete clean sand store with a capacity of approximately 18,000 cubic yards, together with the necessary sludge lagoon, was also substantially completed by direct administration. The laying of new soil and surface water drains was commenced in November by Wallace and Stanley, Ltd., and preparatory work is in progress in connection with the laying of the new roads and pavements required.

Hornsey and Stoke Newington.—Site work by R. G. Horton (Engineers), Ltd., on the construction of two contact and balancing tanks—one of 1¼ m.g. capacity at Hornsey and one of 3½ m.g. capacity at Stoke Newington—continued during the year, the consulting engineers being Messrs. Binnie, Deacon and Gourley.

At Hornsey construction of the mass concrete walls and floor of the tank was nearing completion at the end of the year, and the light precast concrete roofing units were being erected. The embankment of excavated material and consolidated gravel fill surrounding the tank was approximately 50 per cent completed. The foundations to the low-lift pump-house and the building for the chemical treatment plant were laid to ground level.



Pump House Delivery Mains at Ashford Common

At Stoke Newington the main work was concentrated upon taking up, diverting and relaying the existing mains and drains in a congested area. A 60in outlet main was being laid from the contact tank to the existing high-lift pumps.

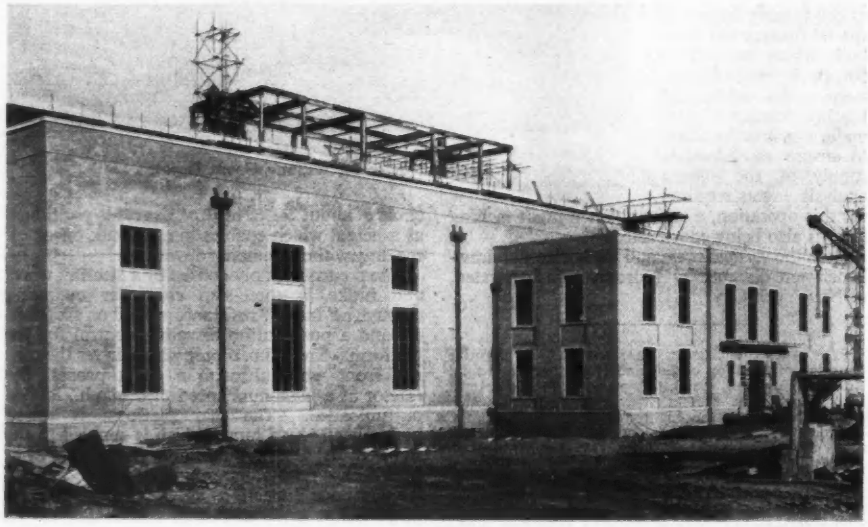
Lee Bridge.—In order to improve the filtration position at this important station, the Board, in December, 1948, approved a scheme for the installation of ten rotary strainers, each 10ft in diameter and 10ft long, arranged in five reinforced concrete chambers and housed in a building situated on the east bank of the Lee Bridge aqueduct. All the rotary strainers have now been delivered and work is proceeding on the construction of the strainer chambers.

Mains.—The 60in trunk main from Kempton Park to Cricklewood when completed will have a total length of 13¼ miles and will convey additional Thames water to North-West and North London. Section No. 1 of the main, a length of 6034 yards, was completed in 1851, and section No. 2, of 4580 yards, in July, 1952. Section No. 3, of 6939 yards, has since been laid by J. L. Eve Construction Company, Ltd., and is now being tested. Good progress was made during the year by J. B. Edwards and Co. (Whyteleafe), Ltd., on section No. 4—Abbey Avenue to Cricklewood—and 4006 lineal yards of main were laid out of a total length of 5726 lineal yards.

The mains scheme from Eynsford and Horton Kirby to Bickley includes the laying of 30in, 24in, 20in, 15in and 12in mains, and the provision of a booster station for the improvement of the supply to the Kent area. The work is now substantially completed apart from the laying of a portion of the 12in main and the booster station, which have been deferred for the time being.

Walton.—The construction of a concrete contact and balancing tank of approximately 2½ m.g. capacity was completed by J. Jarvis and Sons, Ltd., in August, and the installation of two electrically driven raw water pumping units is nearing completion.

General.—During 1952 a second 36in diameter borehole was sunk at Brasted and boiler shells were converted into high-pressure contact tanks at seven of the Board's well stations. The extension of Fortis Green pumping station was completed and the interim scheme for the remodelling of Orpington pumping station was almost finished. Work continued on the final stage of the improvements to the pumping station



Pump House at Ashford Common

at Stoke Newington works and was commenced on the first stage of the scheme for the interim remodelling of Hammersmith pumping station.

Owing to the restriction on new capital works it was necessary to defer commencement on a number of new schemes, of which the most important were the new covered concrete reservoir at Knockholt, the balancing tank at Kew Bridge, and the new pumping station at Chingford.

India's First Five-Year Plan

(From our Indian Correspondent)

A draft outline of the Five-year Plan was published in July, 1951, sixteen months after the inaugural meeting of the Planning Commission on March 20, 1950. Since its publication the Commission has had a series of conferences with the Central and State governments and their experts, with representatives of the principal political parties, members of Parliament and leaders of industry. The final report, presented to the Parliament by the Prime Minister, Mr. Jawaharlal Nehru, on December 8, 1952, is a result of these discussions and consultations, and is a historic document reflecting the long-term financial, industrial and social policies of the Republic's first national government.

THE final report on the Five-year Plan as presented by the Planning Commission is a comprehensive blue-print embodying not only the Five-year Plan as such but an objective analysis of the state of national economy, assessment of resources, financial, social and economic policies to be followed during the period of the plan and suggestions for strengthening and improving the public administration to meet the obligations of a welfare state. The report takes the place of the draft outline presented by the Commission in July, 1951, for "widest possible public discussion."

The present report is divided into three parts. The first part contains an analysis of the process of development in an under-developed economy and indicates the long-term goals towards which national effort is to be directed. At the end of the first part is a summary of the plan and what is sought to be achieved through it. The second part of the report is concerned with administration and public co-operation. In the third part are outlined the various programmes of development: they are grouped under three broad heads, namely: (1) agriculture, irrigation and community development; (2) industry and communications, and (3) social services and employment. Each aspect of development is taken up in turn, needs and resources are assessed and the Commission's proposals for policy and action presented. In a separate volume details are given concerning the principal development schemes included in the plan. The total outlay, estimated at Rs.2068·78 crores,* has been broadly divided between the main heads of developments as given in Table No. I. The draft outline involved an expenditure of Rs.1792·92 crores, of which Rs.300 crores could be undertaken only if external assistance were available. The total outlay on the final plan has thus been increased by Rs.575·86 crores, an increase of over 38 per cent.

TABLE I—*Outlay on the Plan*

Item	Outlay during 1951–1956 (Rupees in crores)	Percentage of total outlay (Rupees in crores)
Agriculture and community development	360·43	17·4
Irrigation and power	561·41	27·2
Transport and communications	497·10	24·0
Industry	173·04	8·4
Social services	339·81	16·4
Rehabilitation	85·00	4·1
Miscellaneous	51·99	2·5
	2068·78	100·0

* Rs. 1 crore = £750,000.

OBJECTIVES

The present *per capita* income of the country is about £20 per annum and the objective is to increase it substantially—preferably to double it—as early as possible. Three important factors have been considered in this connection by the Commission: namely (1) the trend of population, which has been growing at the rate of 1·25 per cent per annum; (2) the relation between investment and output, and (3) the proportion of the increase in national output that can be devoted to investment. In the present plan, capital formation is estimated to rise by about 20 per cent of the additional income each year. The internal resources thus available will to some extent be supplemented by external resources. By 1955–56 (which is the final year of the plan, as this is considered to have begun in 1951) national income will have gone up by about Rs.11,000 crores, i.e. by about 11 per cent. If, from 1956–57 onwards, investment is stepped up each year by about 50 per cent of the additional output, it would be possible to double the *per capita* income in about twenty-seven years from now, i.e. in 1980.

In determining the target of expenditure the main considerations that have been taken into account are: (1) the total resources likely to be available to the country for the purposes of development; (2) the close relationship between the rates of development and the requirements of resources in the public and the private sector; (3) the necessity of completing the schemes already initiated prior to the commencement of the plan; and (4) the need to correct the maladjustments in the economy caused by the war and the partition. Of these, the question of total resources is rather delicate, since there is only one single source of investable resource from which both the private and public sectors have to draw and conditions have to be created whereby the necessary development in the private sector is not impeded. During the plan period it is estimated that public savings, i.e. the savings out of current revenues, will finance about Rs.738 crores of the total expenditure visualised. Private savings likely to be available to the public sector, through loans, small savings, deposits and funds, and other miscellaneous channels, have been estimated at Rs.520 crores. The two sources will thus meet about Rs.1258 crores of the total planned outlay of Rs.2069 crores, i.e. just over 60 per cent. In addition to the normal budgetary resources credit can be taken for external assistance already received from the International Bank, the United States, Canada, Australia, New Zealand, &c., amounting to date to Rs.156 crores. There is still a gap of Rs.655 crores, which has to be met from external resources or, in the absence of it, by additional measures of internal taxation and from deficit financing, which is visualised to the extent of Rs.290 crores. Although, for obvious reasons, the question of external finances has been left somewhat vague by the Commission, there is no doubt, as is clear from some of the statements of the Prime Minister and the Finance Minister, that India would be grateful for assistance from abroad under certain acceptable conditions. Table No. II shows the financial basis of the plan.

TARGETS AND PRIORITIES

"The pattern of priorities to be followed during a particular plan period," says the Commission, "has to take into account the immediate needs of the economy and the desirability of initiating certain long-term changes in the economic structure. The emphasis in the development programme as between different sectors will obviously shift as development in those taken up initially prepares the ground for development in others." For the intermediate five-year period, agriculture, including irrigation and power, have the topmost priority. "Without a substantial increase in the production of food and raw materials needed for industry, a higher tempo of development in the latter cannot be sustained." The development of irrigation and power will, therefore, take up the bulk of the resources available to the public sector, namely, 44·6 per cent. Target for foodgrains has been set up at 61·6 million tons by 1955–56, 7·6 million tons more than the production of 54 million tons in 1950–51. Most of the multi-purpose projects and other schemes, such as fertiliser scheme, have been planned with this ultimate goal of food production in mind.

The Commission's recommendations regarding irrigation and power projects involve the utilisation of both surface and subsoil water. The programme covers multi-purpose irrigation projects,

TABLE II—*Financial Basis of the Plan*

Planned outlay on development (Rupees in crores)	Union Govt. 1241	States Govts. 828	Total 2069
	(Rupees in crores)		
Budgetary resources:			
(1) Savings from current revenues	330	408	738
(2) Capital receipts	396	124	520
(3) Central assistance	−229	229	—
	497	761	1258
External resources already received	156	—	156
Total	653	761	1414
Balance to be found	588	67	655

NOTE.—The balance of Rs.655 crores is to be found from further external resources that may be forthcoming or from internal taxation and borrowing as far as possible and by deficit financing.

TABLE III—*A List of Major Projects Under The Five-Year Plan*

Name of project	Total cost, Rs., crores	Benefits			
		Irrigation (000 acres)		Power (000kW)	
		End of 1956	Total	End of 1956	Total
Bhakra-Nangal, Punjab	132·90	1360	3915	96	400
Damodar Valley, Bihar	74·98	600	1325	150	274
Hirakud dam	62·59	273	1095	85	259
Kakrapara, Bombay	12·16	330	600	24	24
Lower Bhavani, Madras	9·97	165	207	—	—
Malampuza, Madras	3·80	30	40	—	—
Tungabhadra, Madras	18·20	165	250	—	—
Tungabhadra hydro, Madras	7·94	—	—	30	60
Moyar, Madras	4·64	—	—	36	36
Pykara, Madras	4·89	—	—	28	28
Machkund, Madras	6·82	—	—	52	103
Tubewells, U.P.	26·49	175	1533	—	—
Sarda power house, U.P.	7·50	—	—	23	23
Mayurakshi, West Bengal	15·50	600	600	4	4
Tungabhadra, Hyderabad	23·04	200	450	—	—
Godavari, Hyderabad	4·41	40	53	—	—
Nizamsagar, Hyderabad	1·75	—	—	15	15
Bhadra, Mysore	20·00	22	180	—	14
Mahatma Gandhi, Mysore	7·30	—	—	120	120
Shimsha, Mysore	3·20	—	—	51	51
Peechi, Travancore-Cochin	1·73	48	48	—	—
Palliwasal, Travancore-Cochin (second stage)	2·30	—	—	9	9
Sengulam, Travancore-Cochin	2·75	—	—	48	48

NOTE.—This table has been prepared from details given in the draft outline. The final report is understood to give revised estimates (not yet published), which, however, are not expected to differ considerably from those given in the Table.

minor irrigation works, tube-well construction and on the hydro-electric side, generation of power from water resources. Examination of the new irrigation and power projects that are under construction or under investigation, or even only under consideration, throughout the country shows that it will cost about Rs.2000 crores to complete all of them, estimated to add 40,000,000 to 50,000,000 acres to the present 50,000,000 acres, and create additional power of about 7000MW. However, the country's resources are scarcely adequate to finance this ambitious programme at this stage. Even then, irrigation and power have been allotted

TABLE IV—*Some Aims of the Five-Year Plan*

Item	1950–51	Target set for 1955–56	Percentage increase in five years
Agriculture :			
Food grains (million tons)	54·0	61·6	14·03
Cotton (million bales)	2·97	4·22	42·1
Jute	3·3	5·39	66·2
Sugarcane (million tons)	5·6	6·3	12·5
Oilseeds (million tons)...	5·1	5·5	7·85
Irrigation and power :			
Major irrigation (million acres)	50·0	8·5	39·5
Minor irrigation (million acres)		11·2 (69·7)	
Electrical power (million kW)	2·3	3·5	52·1
Industry :			
Iron and steel (million tons) :			
Pig iron (for foundries)	0·35	0·66	88·5
Saleable steel	0·98	1·37	39·8
Cement (million tons)...	2·69	4·8	78·4
Aluminium (thousand tons)	3·7	12·0	230·0
Fertilisers (thousand tons) :			
Ammonium sulphate	46·3	450·0	873·0
Superphosphate ...	55·1	180·0	227·0
Locomotives (numbers)	nil	170	—
Machine tools (Nos. in thousands)	1·1	4·6	318·0
Petroleum refining :			
Liquid petroleum (million gallons)	nil	403·0	—
Bitumen (thousand tons)	nil	37·5	—
Cotton manufacture :			
Yarn (million pounds)	1179	1640	39·0
Mill cloth (million yards)	3718	4700	27
Handloom (million yards)	810	1700	110·0
Agricultural machinery:			
Pumps, power driven (thousands)	34·3	85·0	146·0
Diesel engines (thousands)	5·5	50·0	810·0
Transport :			
Shipping (tonnage) :			
Coastal (G.R.T., thousands)	211·0	315·0	50·0
Overseas (G.R.T., thousands)	173·5	283·0	63·5
Roads (thousand miles):			
National highways ...	11·9	12·5	5·05
State roads	17·6	20·6	17·1

the highest outlay of Rs.561·41 crores, nearly 27·1 per cent of the total. Already a large number of irrigation schemes is in hand. The plan, therefore, aims mainly at the completion of these projects, which, by 1955–56, are calculated to irrigate an area of 8·5 million acres and to generate 1080MW. After completion the total addition to the area irrigated will be 16·7 million acres and to power 1400MW. Minor irrigation schemes will further add 11·2 acres by 1955–56. Table No. III gives a list of some of the major hydro-electric and irrigation projects with an estimate of benefits accruing from them.

In the sphere of transport and communications, railways have been allotted Rs.400 crores, about Rs.80 crores per year. The regrouping and nationalising of railways accomplished early this year was a major step towards the implementation of an integrated policy as regards transport. Already a number of contracts have been signed abroad for the manufacture and supply of coaches, wagons, locomotives and other parts. The old East Indian Railway workshop at Jamshedpur has been taken over and turned into a modern plant for the manufacture of locomotives and under-carriages. Of the total expenditure of Rs.400 crores, the railways themselves will have to find Rs.320 crores from their revenues and resources. The total provision for road development is about Rs.74 crores for the completion of about 450 miles of new roads and forty-three very large bridges. In addition, about 2200 miles of roads will be improved. It is proposed to nationalise civil aviation and Rs.9·5 crores have been provided for the payment of compensation and for the purchase of new aircraft. Shipping and ports also come in for an aggregate expenditure of about Rs.30 crores. As railways, ports and shipyards are run by quasi-autonomous corporations and boards, the expenditure visualised is only a part of the total outlay, the rest being provided by the individual boards.

In industry the bulk of the field has been left open for private enterprise. The Commission has worked out detailed programmes for forty-two organised industries in close consultation with representatives of the industries concerned. The total capital investment necessary for industrial expansion in the private sector is estimated at Rs.233 crores. About 80 per cent of this would be in respect of capital goods and producer goods industries. The major ones among these are iron and steel, which is estimated to take up Rs.43 crores, petroleum refineries (Rs.64 crores), cement (Rs.13 crores), aluminium (Rs.9 crores), fertilisers, heavy chemicals and industrial alcohol (Rs. 12 crores). In the case of consumer goods industries, considerable investment is envisaged in certain new lines, such as rayon, paper, drugs and pharmaceutics. Taking into account the investment needed by way of working capital and certain other items, the overall requirements of finance for industry amount to about Rs.700 crores.

As regards foreign capital, the broad principle is that " foreign investment should be permitted in spheres where new lines of production are to be developed or where special experience and technical skill are required or where the volume of domestic production is small in relation to demand and there is no reasonable expectation of indigeneous industry being able to expand at the desired rate." Agreements for joint participation between foreign and Indian capital are to be approved by the Government. Already the Burmah-Shell and Standard-Vacuum companies have set up their organisations for the construction of the first large refineries in India and Caltex is expected to follow suit. Several other enterprises, mainly in the motor and cycle industries, have been organised with joint participation of capital. Plans are afoot for a new iron and steel project estimated to cost Rs.30 crores by 1955–56 and Rs.80 crores for completion. Targets in the major spheres as laid down by the Commission are given in Table No. IV.

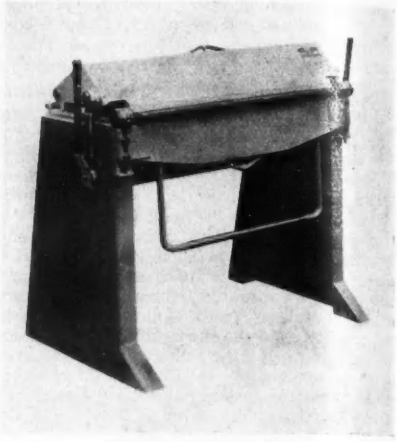
It must be remembered that the plan is considered to have begun in March, 1951. For example, Rs.153 crores have already been spent on some of the projects and a number of schemes scheduled under the plan are pretty well advanced. A start was made on October 2nd on the community projects and some of the minor irrigation schemes. The Damodar Valley schemes are quite advanced and arrangements are being made for the commissioning of the first sets at Bokaro and Tilayya. The plan, according to the Finance Minister, Mr. C. D. Deshmukh, has on the whole been received with " quiet optimism " and up to the moment of writing has found negligibly few serious critics, either among economists or the opposition leaders.

A Universal Folding Machine

THE photograph we reproduce herewith shows one of the redesigned universal sheet metal folding machines which are now being made by F. J. Edwards, Ltd., 359, Euston Road, London, N.W.1, in three models with capacities up to 36in, 48in and 72in. The machines can be used for forming sections in mild steel up to and including 18 gauge sheet.

The rigid pressed sheet steel end frames of the machine are coupled with a heavy pressed steel channel section tie bar and their design imparts a clean modern appearance to the machine. A triangular box-section clamping beam fabricated from heavy steel plate has adjustable stress bars, and the folding beam of similar plate construction also has an adjustable stress bar. The clamping beam is lever operated and front to back adjustment is provided for various thicknesses of material and to allow for aligning the beam and bed. A sharp edge blade is fitted and, if required, radius blades can be supplied.

The folding beam is hand operated from the front of the machine by direct pull and is adjustable in the side arms for radius bends. An angle blade fitted to the beam to give it a wide working face, is removable for making narrow return or Z bends in light gauge material. An adjustable angle stop for repetition bending



Universal Folding Machine

is in the form of a toothed segment at each end of the beam.

The bed has a special bar at the clamping edge to give nominal sharp edge bends in 18 S.W.G. material, and it can be changed for bars of less height, which, together with the adjustment of the folding beam in the side arms and the use of suitable round nose blades on the folding beam, allows true radius bends to be formed. Special bars of various widths at the clamping face can also be supplied for small return or Z bends and mouldings, the clamping beam having enough lift to allow bends of this type, within the capacity of the machine, to be withdrawn.

Development of Prestressed Concrete Structures in South Africa

THE first prestressed concrete bridge to be built in South Africa has recently been completed over the Umbilo Canal for the Durban Corporation. Other similar projects to be carried out in due course are the Valsche River Bridge at Bothaville and also the Wyebank Bridge on the Durban-Pietermaritzburg road.

The roofs of the new paper mill at the mouth of the Tugela river will represent one of the largest prestressed concrete structures in the world. The main machine-house of the mill, which belongs to the South African Paper and Pulp Industries, is 600ft long and is covered by prestressed concrete beams spanning 85ft without any internal supports.

Several multi-storeyed buildings, using prestressed concrete beams, have also been completed. The most notable of these is the Groote Kerk building in Pretoria, completed a few months ago. The beams were manufactured in Durban, railed to Pretoria and lifted from the first to the eighth storey. In spite of these extra carriage and handling costs it is estimated that the total cost was less than it would have been if the orthodox building methods of construction on site had been employed.

An application new to South Africa is the making of prestressed concrete sleepers. They are being tried out on privately-owned sidings, and will, presumably, win official recognition as a substitute for wooden sleepers when time has proved the claims of the makers—that these sleepers are not only cheaper than wooden ones but have a much longer life.

Industrial and Labour Notes

Britain's Overseas Trade

The *Trade and Navigation Accounts* for December, 1952, which have been published this week by the Board of Trade, give the final value for last year's exports of United Kingdom goods as £2550 million, which was £30,000,000 below the 1951 figure. The Board of Trade says that, after reaching a record of £718 million in the first quarter of last year, exports fell to £628 million in the second quarter, following the import restrictions imposed by many of the Commonwealth countries. Holidays caused a further decline in the third quarter, but there was a partial recovery in the final quarter of the year to about the same level as the second quarter's exports. The general level of export prices last year was substantially higher than in 1951. The Board of Trade estimates that the volume of exports of United Kingdom goods last year was 6 per cent less than in 1951. It was the first year since the war that the volume of exports has shown a decrease.

Iron and Steel Production

Figures for iron and steel production in the month of December and for the whole of last year were issued at the end of last week by the British Iron and Steel Federation. The December figures reflected the full effect of both the Christmas and New Year holidays as 1952 in the steel industry was a fifty-three week year ending on January 3rd. Steel output in December averaged 313,700 tons a week and was thus at an annual rate of 16,314,000 tons, compared with an annual rate of 14,953,000 tons in December, 1951. Steel production for the whole of 1952 totalled 16,418,000 tons in the fifty-three weeks. The output of 16,000,000 tons which it was hoped would be achieved was actually surpassed in the fifty-two weeks ended December 27th, when production amounted to 16,138,000 tons. Pig iron output in the full year amounted to 10,728,000 tons, compared with 9,669,000 tons in 1951.

The British Iron and Steel Federation says that in each of the four concluding months of 1952 record levels of steel production were reached. The year's result was brought about primarily by the progress towards completion of the iron and steel industry's first development plan, which was launched in 1946 and is due for completion by the middle of this year. The new blast furnaces which came into operation last year made it possible to increase pig iron output by over 1,000,000 tons. The increased steel production last year was based entirely on a higher pig iron consumption, the quantity of scrap consumed in steel-making being rather less than in 1951. To feed the new blast furnaces more than 3,000,000 tons of additional iron ore had to be provided, consumption of home ore having been raised from about 14,000,000 tons in 1951 to over 16,000,000 tons in 1952, while imported ore consumption increased from about 7,750,000 tons to over 8,750,000 tons. In addition to the home production of steel, the British Iron and Steel Federation estimates that imports last year amounted to 1,800,000 ingot tons compared with 560,000 tons in 1951. This means that available supplies last year totalled 18,480,000 ingot tons. With exports held down to about 2,600,000 ingot tons, last year's home deliveries of steel have been put at 15,880,000 tons.

As to the coming year, the British Iron and Steel Federation says there would seem to be no reason why any desirable programmes for export or capital investment should be limited by shortage of steel. As full benefit is derived from the recently-completed blast furnaces, pig iron production this year should increase by about 1,000,000 tons over the 1952 total. Steel production will benefit, not only from the larger supply of pig iron and the automatic increase in circulating scrap, but also from the fact that there will be no need to replenish stocks of steel-making materials as there was during the past year. It should therefore be possible for the industry to reach the production objective of 17,500,000 tons, which it has set itself for 1953. Moreover, last year, the Federation says, a substantial quantity of steel—at least 500,000 ingot tons—was added to producers" merchants', and consumers' stocks. The prospective increase in available supplies in this present year may thus be of the order of 2,000,000 tons, which, it is thought, should be more than ample to meet the requirements of all the programmes at home.

Industry and the Universities

The Federation of British Industries has now published, in the form of a booklet, a full report of a conference on "Industry and the Universities," which was held at Nottingham in September last. The conference was organised by the North Midland Regional Council of the F.B.I. and the University of Nottingham, and was the sixth of such conferences to be held, since 1949, at Oxford, Bristol, London, Leeds and Birmingham. The Nottingham conference was attended by 115 delegates, and, like its predecessors, emphasised the great importance to the nation of close co-operation between the universities and industry.

During the discussions, and in the various addresses which introduced them, several proposals were put forward for further consideration. It was suggested, for example, that industry and the universities should aim at establishing close relationships with a minimum of formality, and that the possibility should be examined of establishing at some universities post-graduate schools of business administration designed for graduates who have already spent from three to five years in industry. Other suggestions were that a study should be made of the difficulties experienced by the small firms in absorbing technical and non-technical graduates ; that industry and the universities should co-operate to a greater extent in the planning of post-graduate courses in technology ; and that industry should consider whether it could provide the universities with more material for research and teaching.

The report now published states that, with the unanimous approval of the conference, a small joint committee has been appointed to examine and work upon the various practical proposals put forward. It is hoped that the committee's work will go far to strengthen the already strong ties of mutual understanding and co-operation which link Nottingham University and local industry.

The Economic Position

At the beginning of this week the Federation of British Industries and the National Union of Manufacturers issued a joint statement on the economic position. Its contents have been inspired by the conviction of the two organisations that the attainment of permanent stability in the balance of overseas payments is primarily dependent upon an internal monetary and fiscal policy which will encourage the development and efficiency of industry. The statement begins by saying, once more, that the immediate need for the United Kingdom is a further increase in exports. This, it is remarked, places a heavy duty on British industry, which it is anxious to discharge. But it is a task in which industry cannot succeed unless the Government and the people recognise that certain conditions are essential to any prospect of success.

According to the statement, the key lies in the ability to compete and that, it is asserted, must rest upon efficiency of production. The great need is to reduce cost without impairing quality. To achieve that, the statement continues, a much more rapid programme of development and re-equipment is required, sufficient progress in that direction having been prevented in recent years by financial stringency. The statement goes on to remark that taxation is so eating into profits as to leave industry with insufficient funds to maintain efficiently even the existing scale of operations because of the inability to set aside enough to replace fixed assets at enhanced costs and find the working capital to match the rise in price levels. If expansion of production and exports is essential, it is emphasised, much more than mere maintenance of operations is required, and every encouragement must be given to the will to take risks.

The organisations responsible for the statement say that they appreciate that taxation cannot be significantly lowered without a reduction in national and local government expenditure and agree that there may be difficulty in determining where that should take place. Their statement says it is not for industry to indicate where the cuts should be made ; it can speak with authority only on the effect of the failure to make them. The view expressed in the statement is that a permanent increase in overall production and exports will not be achieved until taxation has been materially reduced. Acknowledgment is made of the success of the measures adopted by the Government to arrest the drain on the financial reserves and avert national bankruptcy. The Federation of British Industries and the National Union of Manufacturers accept that it was inevitable that those measures should have taken, in the main, the form of curtailing imports and capital investment. The statement again directs attention to the fact, however, that, being restrictionist in nature, such measures militate against the expansion of international trade which is fundamental to the correction of economic instability.

Inland Transport in Europe

The United Nations Economic Commission for Europe has published this week its *Annual Bulletin of Transport Statistics*. The tables and other information contained in it relate to the year 1951, when in thirteen Western European countries rail freight traffic was 15 per cent higher than in the preceding year, and traffic by inland waterways was 18 per cent higher. Road freight traffic appears also to have increased in 1951 compared with 1950, in the Western European countries for which figures have been made available. The *Bulletin* says that passenger traffic by rail in Western Europe was, on the whole, a little higher in 1951 than in 1950. Comparing the number of rail journeys per head of population in 1951 with that of 1938, it is shown that only in the United Kingdom and in Western Germany has there been a decrease. In 1951 the highest number of journeys per head of population was in Switzerland, the next in Luxembourg, and the third in Western Germany. The lowest number per head of population was in Turkey.

Industry in Northern Ireland

The Government of Northern Ireland has introduced a Re-equipment of Industry (Amendment) Bill, which clarifies the powers of the Ministry of Commerce to pay grants towards re-equipment carried out under schemes started before submission to or approval by the Ministry. Under this Bill the time limit is extended to January 1, 1954, for the submission of schemes carried out between May 18, 1950, and January 23, 1951. It allows the Ministry to treat applications for assistance under the Industries Development Acts, 1945 to 1950, as applications under the Re-equipment of Industry Act, if that is more appropriate.

The Re-equipment of Industry Act empowers the Ministry of Commerce to make grants to manufacturing firms on approved schemes of re-equipment or modernisation designed to increase their productive efficiency. So far, over 150 applications have been received by the Ministry, involving schemes totalling about £8,000,000. Over ninety schemes, valued at approximately £5,300,000, have so far been approved, and it is stated that, by the end of last year, grants totalling over £370,000 had been paid.

Notes and Memoranda

Air and Water

H.M. MINESWEEPER "BRIGHAM."—Her Majesty's Inshore Minesweeper "Brigham," was launched on Saturday, January 17th, from the shipyard of the Berthon Boat Company of Lymington.

PLASTIC BOATS.—For some years the Admiralty has been investigating the possibilities of building small boats of plastic material and for the last two years has had under test two fibre glass plastic dinghies. The results are promising and further investigations are in hand to use the technique for boats of more complicated construction.

MAIDEN VOYAGE.—The French Line announces that the S.S. "Antilles," of 20,464 tons gross, which has been built by the Arsenal de Brest, will make her maiden voyage on April 30th, when the ship joins the S.S. "Colombie" in the company's West Indies service. With a speed of 22 knots the new liner will be able to make the round trip to Jamaica and back in four weeks.

MARINE RADIO OFFICERS.—We have received from the Marconi International Marine Communication Company, Ltd., a copy of a brochure entitled "Marine Radio Officers," which generally discusses the profession of a radio officer, its advantages and the opportunities for study while at sea. The booklet contains a number of photographs which serve to illustrate the equipment in use, the accommodation provided on board ship, and some of the parts of the world visited by the shipping companies.

RADAR AND ICE.—A paper entitled "Radar and Ice" was read by Mr. L. S. Le Page and Mr. A. L. P. Milwright at a meeting of the Institute of Navigation, which was held in London on Friday last, January 16th. The paper gave an account of some experiments conducted in Hudson Bay, between the end of June and the end of August last year, aboard the ice-breaker "N. B. McLean," to determine the effectiveness of radar in ice conditions. A great deal of summer ice of all descriptions was observed, from soft pack-ice to bergs of up to 200ft in height, and was recorded photographically. Detailed radar measurements were carried out on about sixty ice formations, and measurements of the formations and of meteorological conditions were made. As a result of the investigations, one of the conclusions recorded by the authors of the paper was that radar was an invaluable aid to ships navigating in bad visibility in ice infested waters, provided it was wisely used and its limitations were known. Several recommendations for improving the performance of marine radar sets in ice were made in the paper.

A SYNTHETIC RADAR TRAINER.—The Ministry of Civil Aviation Air Traffic Control Experimental Unit has developed a radar trainer that will synthesise the flight paths of aircraft as seen by any modern surveillance radar and, in addition, will permit the flight paths of aircraft to be altered independently at will. The overall conception of the trainer is based on electro-mechanical calculations, which continuously calculates the position in range and bearing of the synthetic aircraft from the radar site. The angular position of shafts representing range and bearing are used to produce a short pulse, which appears in the correct position on the normal radar planned position indicator. In order to make the trainer independent of actual radar equipment, all the normal data usually obtained from the real equipment are produced artificially—aerial turning information, time-base trigger, range markers and permanent echoes. The new trainer will effect a considerable financial saving by reducing the period required to train air traffic control officers as traffic directors. The principles have also been applied to another device—a simulator—to assist in experiments and investigations in the development of air traffic control techniques and procedures. Although such equipment cannot remove completely the need for full-scale, costly tests with real aircraft, it will reduce them to a fraction of what they would otherwise be. It will also enable problems to be simulated that cannot well be reproduced in trials. Work on the simulator is well advanced and the first unit, providing six simulated movements, will be available shortly. Equipment to simulate movements of twenty aircraft at one time is being planned. The new synthetic trainer has aroused considerable interest in the aviation world and a number of commercial organisations are planning to make use of the design.

Rail and Road

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—Mr. Peter Smyth, managing engineer in the operations department of the Shell Petroleum Company, Ltd., has been elected a vice-president of the Institute of Road Transport Engineers. A new group of the Institute—to be known as the North-East of England group—has recently been started to serve the North Riding of Yorkshire, Northumberland, and County Durham.

MEN AND MACHINES IN TRANSPORT SYSTEMS.—The Operational Research Club and the Ergonomics Research Society are arranging a joint open meeting, on February 13th, on the subject of "Men and Machines in Transport Systems." It is to be held at the Royal Society, Burlington House, Piccadilly, London, W.1, beginning at 2.30 p.m. The discussion will be opened by the three following papers :—"Some Factors Influencing the Road Behaviour of Vehicle Drivers," by Mr. R. J. Smeed; "Pedestrian Choice and Judgment," by Mr. R. L. Moore; and "Some Measures of Driver Behaviour," by Mr. R. E. F. Lewis.

LIGHTWEIGHT TRAIN ON LONDON TRANSPORT.—The first complete train of light alloy rolling stock on the London Transport system has been placed in service on the District Line. For some months individual cars of light metal construction have been running on that line, and the recent delivery of light metal cars with driving cab positions permitted the formation of a complete eight-car train. The new cars are based on steel prototypes, being similar in all external aspects; they are also fitted with identical steel bogies and electric traction and auxiliary equipment. The new train weighs nearly 50 tons less than a comparable steel train, the individual cars weighing an average of 5¼ tons less than the steel cars. The introduction of this complete train of light alloy stock will allow direct comparison of energy consumption with that of a corresponding steel train.

Miscellanea

SOUTH SHIELDS DEVELOPMENT PLAN.—The Minister of Housing and Local Government has approved with modifications the development plan for the County Borough of South Shields.

BRONZE ALLOYS.—A new publication of J. Stone and Co. (Charlton), Ltd., Woolwich Road, London, S.E.7, gives in tabular form the mechanical and physical properties and some typical applications of the various bronze alloys made by the firm.

DEFENCE RESEARCH APPOINTMENT.—The Ministry of Supply announces the appointment of Dr. Walter Cawood, C.B.E., as Principal Director of Scientific Research (Defence). He follows Dr. O. H. Wansbrough-Jones, C.B., who, as already announced, is succeeding Sir Harry Garner, K.B.E., as Chief Scientist at the Ministry of Supply. Dr. Cawood, who is forty-five, has been a deputy director at the Royal Aircraft Establishment since 1947.

FIRST FACTORY AT BASILDON NEW TOWN.—The first factory to start production at Basildon New Town, Essex, is that taken by Rotary Hoes, Ltd., Horndon, Essex, for the manufacture of the "Platypus" tractor and other equipment. The tractor was described in our issue of December 12th, 1952. The first section of the factory was officially opened at a recent ceremony, and a second section is expected to be ready in about three months' time. An administration block will be added by the end of the year, the whole factory occupying a site of 12 acres.

ASLIB STUDY COURSE.—Aslib has announced some particulars of a study course on "Sources of Information," which is to be held at its headquarters at 4, Palace Gate, London, W.8, from Thursday, February 19th, to Sunday, February 22nd. The course, which will be introduced by Dr. V. E. Parke, intelligence officer of Imperial Chemical Industries, Ltd., Billingham Division, will include eleven lectures, followed by discussions, and a visit to a library. The fee for the course is £3 3s. and application should be made immediately to the headquarters of Aslib at the address given above.

CONSTRUCTIONAL STEELWORK FILM.—A 16mm film entitled "A Job for a Man" has been produced by the British Constructional Steelwork Association to illustrate the fabrication of all classes of constructional steelwork. The film, which has been made under the direction of Mr. John Byrd and includes a commentary by Mr. Neil Arden, is intended primarily for youths and boys about to select a career. But all who are concerned in any way with constructional engineering will undoubtedly find much of interest in it. The film runs for thirty minutes. It will shortly be available for loan to secondary and technical schools and to any other organisations interested in the selection of careers for youths. Application for it should be made to the Association at 94–98, Petty France, London, S.W.1.

DR. HANS CARSTEN.—We regret to learn of the death of Dr. Hans Carsten, Dr. Eng., M.I.E.E., F.Inst.P., who, for eleven years, had been consultant telecommunications engineer to British Insulated Callender's Cables, Ltd. Dr. Carsten was a mathematician and physicist widely known for his work on telecommunications and cable measurement techniques. He received his technical training at Danzig University, where he was awarded the degree of Dr. Eng. After a short period in the Telegraph Research Station of the German Post Office he joined the Central Laboratory of Siemens and Halske in 1922 and eight years later was transferred to the transmission cables sales department. He left Germany before the war and joined British Insulated Callender's Cables, Ltd., in 1941.

FUEL CONTROL ORDERS REVOKED.—The Ministry of Fuel and Power states that six orders relating to the control of coal and coke supplies, which were issued during the war, and are no longer required, are revoked as from Thursday, January 22nd. These Orders are: the Coal Supply Order, 1942, relating to directions given by the Minister in certain quarters as to the disposal and treatment of coal and coke; the Fuel Consumption (Information) Order, 1942, relating to the collection of returns from coal consumers; the Ministry of Fuel and Power (Seizure of Fuel) Order, 1942, empowering the seizure of fuel by public authorities in certain circumstances; the Fuel (Inspection) Order, 1943, permitting officers authorised by the Minister to inspect vehicles on which fuel was being carried, and the Legal Proceedings (Local Fuel Overseers) Orders of 1942 and 1944, providing for prosecutions for breaches of Fuel Orders to be undertaken locally instead of centrally.

Personal and Business

THE HAWKER SIDDELEY GROUP announces that Mr. J. F. Robertson has been elected to the board of directors.

THE BRITISH ELECTRICITY AUTHORITY announces the appointment of Mr. R. D. V. Roberts as deputy director of welfare.

MR. H. SOMERVILLE SMITH has been elected a director of British Overseas Engineering and Construction Corporation, Ltd.

MR. ROWLAND E. HARVEY and Mr. D. Keith-Lucas, M.I.Mech.E., F.R.Ae.S., have joined the board of Short Bros. and Harland, Ltd., Belfast.

MESSRS. C. MACKECHNIE JARVIS AND PARTNERS, consulting engineers, have moved to 53, Victoria Street, Westminster, S.W.11 (telephone, Abbey 4751).

METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., states that Mr. C. H. de Nordwall, M.I.E.E., has been appointed manager for South America.

COVENTRY CLIMAX ENGINES, Ltd., Widdrington Road Works, Coventry, states that its telephone numbers are now as follows: Coventry 62607 (head office and works); and Coventry 5051 (service and spares).

DR. T. E. ALLIBONE, F.R.S., has been appointed to the board of the Edison Swan Electric Company, Ltd., as director of research. He retains his position as director of the A.E.I. Research Laboratory, Aldermaston.

POLDI (ENGLAND) SUCCESSORS, Ltd., 4, Machon Bank, Sheffield, 7, announces that it has taken over the complete selling organisation and manufacturing programme in this country of Poldi Steel Company (England) Ltd.

THE ELECTRICAL POWER ENGINEERING COMPANY (BIRMINGHAM), Ltd., announces that Mr. W. A. Biggs, A.M.I.E.E., has been appointed London manager, in place of Mr. A. N. D. Kerr, who is leaving the company's service. The London office is at 421, Grand Buildings, Trafalgar Square, W.C.2.

MR. E. L. CADWALLADER is retiring from his executive appointment with C.A.V., Ltd., Acton, London, W.3, but will continue to serve on the board as consulting director. Mr. H. G. Mason, who has been with the C.A.V. organisation for twenty-six years, has been appointed joint general manager.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, announces that Professor Willis Jackson, D.Sc., M.I.E.E., will join the board on July 1st and take up the full-time appointment of director of research and education. Dr. C. Dannatt is relinquishing that appointment in view of an extension of his present duties as assistant managing director.

Contracts

MIRRLEES, BICKERTON AND DAY, Ltd., of Stockport, has received an order, worth more than £200,000, for a new power station to be built at Ashford, Kent by the British Electricity Authority. The order is for five 2000kW sets, each driven by a Mirrlees "KVSS 12" engine, developing 2900 b.h.p. and capable of running on low-grade fuel oil. The engines will be direct-coupled to Brush alternators with an output of 2500kVA at 6·6kV and 428 r.p.m. Two sets are due for completion by October, 1954, and the others by the following autumn. The installation will enable the South Eastern Electricity Board to defer reinforcement of a section of its transmission system.

DURING December, 1952, the British Electricity Authority placed contracts for equipment for power stations, transforming stations, and transmission lines amounting in the aggregate to £5,373,691. The principal contracts include: Marchwood power station, near Southampton, condensing and feed heating plants for four 60MW turbo-generator sets (Hick, Hargreaves and Co., Ltd.); Brimsdown power station, near Enfield, four reinforced concrete housings for electrostatic precipitators and two natural draught reinforced concrete cooling towers and ponds (Beirrum and Partners, Ltd.); Ince power station, near Ellesmere Port, two brick chimneys (D. Theaker and Co., Ltd.); Wakefield power station, Yorks, 132kV, 2500MVA switchgear (A. Reyrolle and Co., Ltd.); Skelton Grange power station, Leeds, 132kV, 2500MVA switchgear (British Thomson-Houston Company, Ltd.); Clyde's Mill power station, Glasgow, ash handling plant (Babcock and Wilcox, Ltd.); Ince substation, site and foundation works (A. Monk and Co., Ltd.); Creyke Beck substation, Yorkshire, site and foundation work (George Houlton and Sons, Ltd.); Stella North substation, near Newcastle upon Tyne, site and foundation works (Sir Robert McAlpine and Sons, Ltd.); Carrington substation, near Manchester, 132kV cables (W.T. Glover and Co., Ltd.); Drakelow, Burton-on-Trent, to Carrington (near Manchester), 275kV twin 0·4 square inch overhead line (British Insulated Callender's Construction Company, Ltd.) and Keadby, Scunthorpe, to Ferrybridge, 275kV overhead line (Watsham's, Ltd.). Orders have also been placed with the following firms for a number of diesel generating sets, to be installed in the power stations indicated:—Mirrlees, Bickerton and Day, Ltd., two 2000kW sets (Walsall), three 1330kW sets (Lister Drive, Liverpool), and one 2000kW set (Macclesfield); Ruston and Hornsby, Ltd., one 1040kW set (Basingstoke); English Electric Company, Ltd., one 950kW set (Clacton), and two 950kW sets (Southend).

British Patent Specifications

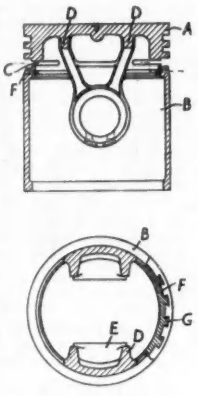
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

INTERNAL COMBUSTION ENGINES

684,866. June 6, 1950.—Improved Pistons, Karl Schmidt G.m.b.H., Neckarsulm, Württemberg, Germany.

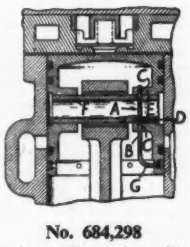
The invention is concerned with utilising the greater increase in heat of the piston head and adjoining gudgeon pin sockets for controlling the upper part of the piston skirt. The piston consists of the head *A* and the skirt *B*, the two parts being separated from one another by slots *C*. The connection between *A* and *B* is made by ribs *D* on the piston head. They run along the axis of the gudgeon pin and continue as far as the gudgeon pin sockets *E*. In the upper part of the skirt is anchored a circular, closed ring *F* of iron or ferrous alloy, which serves to control the variation of shape of the skirt during working. It is advantageous to provide the ring with lateral projections *G*, by which it is anchored in the piston wall. If desired, more than one ring *F* may be provided. It is claimed that the construction of the rings *F* as closed flat rings of constant thickness around the periphery firmly anchored to the skirt causes the ring to expand during operation in the direction of the axis of the gudgeon pin so as to draw in the pressure and counter-pressure sides of the piston skirt and cause the oval cross section of the piston to approach the circular form.—*December* 24, 1952.



No. 684,866

684,298. April 23, 1951.—Pistons, Bendix-Westinghouse Automotive Air Brake Company, 901, Cleveland Street, Elyria, Ohio, U.S.A.

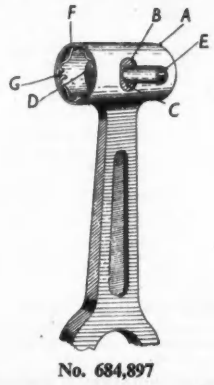
The invention relates to an improved construction for locking a piston pin in the piston. The drawing shows the general arrangement of a piston in the engine cylinder. The locking device consists of an L-shaped pin *A* of round spring wire and provided with a long arm *B*, projecting through aligned openings *C* and *D* in the boss *E* and in the piston pin *F* respectively. A short arm *G* is sprung into one of the oil return openings to lock it in a vertical plane. When the parts occupy the positions shown, the piston pin is securely locked and it can be easily and readily removed from its locked position when necessary.—*December* 17, 1952.



No. 684,298

684,897. February 27, 1951.—Engine Connecting-Rods, Julian Tarraga Revilla, calle Mayor de Reinosa, No. 3, Bejar, Salamanca, Spain.

The connecting-rod has its small end *A* formed with two diametrical elongated openings *B* and a cross pin



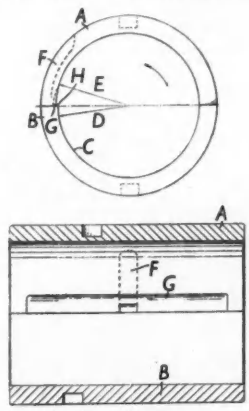
No. 684,897

C in the bore of the small end is hollowed at *D* at each end to reduce weight while maintaining sufficient rigidity. It is provided with a central opening, into which is inserted a sleeve *E* of non-ferrous material to afford a bearing for the piston gudgeon pin. When the cross pin *C* is mounted in the bore of the small end it is retained against end play by means of irregularly bent wire clips *F* engaged in grooves *G* in the ends of the bore. When the piston is placed over the small end it is connected to the rod by inserting the piston gudgeon pin into the pin bosses of the piston and through the elongated openings of the small end and the bush or sleeve which has previously been inserted in the opening of the cross pin *C*. The oscillatory motion of the pin *C* is the essential feature enabling the piston to align itself perfectly at all points of its travel in the cylinder, since at no point is the piston constrained to take a certain direction by reason of faulty alignment of the connecting-rod.—*December* 24, 1952.

BEARINGS AND SUPPORTS

684,247. January 23, 1950.—Plain Bearings, The Glacier Metal Company, Ltd., 368, Ealing Road, Alperton, Wembley, Middlesex. (*Inventor: Phil Prince Love.*)

The invention relates to improvements in bearings which are especially applicable for use in grinding machines and other precision machine tools, wherein it is important that a spindle be accurately located when under load. As the drawings show, the journal bearing consists of two halves *A* and *B* and is machined so that the bore *C* instead of being circular in cross-section, is of spiral section. The profile is such that the profile slope bears a relationship to the clearance, which may be exponential, constant or hybrid, according to the conditions of side leakage. In



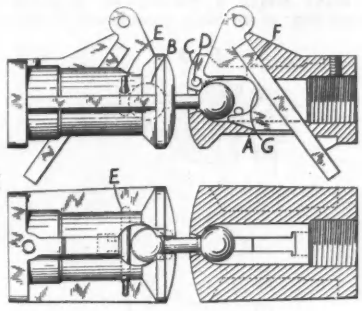
No. 684,247

practice, the variation in clearance may be, for example, from about 0·001in at *D* to 0·005in at *E*. The variation in clearance may be determined experimentally according to the particular conditions of speed, length of bearing, viscosity of oil, and whether the ends of the bearing are open or restricted, by providing a series of tubes connecting various points around the periphery of the bore with pressure gauges, and modifying the curve constant until, under the given conditions, all pressure readings are substantially the same under conditions of no load. The direction of rotation of the journal is from maximum clearance to minimum clearance and oil is introduced through a passage *F* and groove *G* at or in the vicinity of the point of maximum clearance. A feature of the bearing profile is, in operation, a continuous smooth surface around substantially 360 deg., there being a step *H* from the minimum clearance to the maximum clearance provided.—*December* 17, 1952.

MINING ENGINEERING

684,320. July 1, 1949.—Vehicle Couplings, National Coal Board, Hobart House, Grosvenor Place, London, S.W.1, and Harold Edward Dudley, Valsfield, Wynnstay Lane, Marford, Flintshire.

The invention relates to couplings for rail vehicles, more especially mine cars for coal and other minerals, which are tipped by rotation about the coupling axis. As shown in the drawings, the coupling has a socket member *A* on one of the vehicles and a similar member with a coupling piece or bar *B* on the other. Each socket member is cylindrical and is coaxial with a drawbar to which it is screwed. One end of the socket member passes through a hole in the vehicle headstock and within the headstock it is surrounded and compressed by a helical spring in such a way that the member serves as a resilient buffer and also as a resilient towing means. The socket member is formed with a cylindrical axial bore which is closed except for an axial passage of reduced diameter which is open to the upper edge of the enlarged head through a slot *C*. Behind the axial passage is formed a part spherical seating, and above the seating there is an enlarged opening communicating with the slot and extending to the upper surface of the socket. A pair of spring-loaded balls *D* in the sides of the slot form a restricted throat in the slot. The coupling member or bar *B* is of dumbbell or hambone shape and is received within the bores of the socket members as shown in the drawings. A removable pin *E* behind the head is provided for holding the head up to the seat in one member of the coupling. The coupling member may be swung by rotation of the head in its seat and by movement of the shank of the coupling upwards to a position in which the free end of the bar is substantially above the level of the socket member. The bar is retained in this position by the



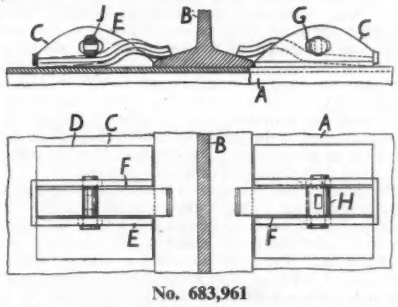
No. 684,320

spring-loaded balls. Each socket member is provided with a sliding coupling and uncoupling device *F* of T-section which can slide in a slot extending upwards and forwards at an angle of about 60 deg. to the axis of the member. The leg of the T-section is presented forwards (i.e. towards the buffing head), and is formed with a horizontal notch *G*. The device is arranged for sliding movement into a position in which the notch is substantially above the top of the socket and arranged for reception of the free end of the coupling bar attached to the companion vehicle. It can be slid down to carry the end of the bar into the bore of the socket member and hold it therein. In the coupling position the head of the bar has a limited degree of axial freedom in the socket. During the downward movement of the coupling device the shank of the dumbbell passes through the slots of the two socket members, and when in the coupling position the two heads of the dumbbell engage with the two spherical seats. Supported in bearings on the end of each vehicle above the coupling there is arranged a lever-operated mechanism by which the coupling bar is elevated to the position for reception of the free end of the coupling dumbbell and the dumbbell lowered into the coupling position.—*December* 17, 1952.

RAILWAY ENGINEERING

683,961. February 6, 1950.—Securing Railway Rails to Sleepers, Elastic Rail Spike Company, Ltd., Cory Buildings, 117, Fenchurch Street, London, E.C.3, and Henry Edgar Thompson, 73, Fairdene Road, Coulsdon, Surrey.

As illustrated in the drawings, fastening means are applied to the sleeper *A* at both sides of the rail *B*. Each comprises a pair of L-section metal brackets *C* having horizontal arms *D* extending away from each other, and their vertical arms spaced about 1¾in apart. For use with each pair of brackets *C* there is



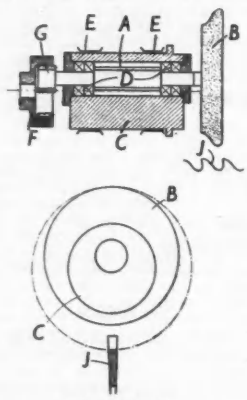
No. 683,961

provided a clip *F*, made from a strip of spring steel folded upon itself. For applying downward-directed pressure to the clip, the vertical arms of the bracket are provided with aligned perforations *G* of substantially elliptical shape. A transverse pin *H* is provided with a central portion *J* flattened in cross section conforming to the shape of the holes *G*, but made slightly smaller so that, with the major axis of the central portion *J* lying horizontally, the pin is free to be engaged in the hole by endwise movement, the central portion then lying in the space between the two vertical arms of the brackets and above the intermediate part of the clip. When it is desired to remove the clip, it suffices to rotate the transverse pin back to its initial position to relieve the clip of pressure and the pin can then be pushed or knocked out. Modified designs are also shown in the specification.—*December* 10, 1952.

TOOLS AND WORKSHOP APPLIANCES

684,741. May 11, 1951.—SAW SHARPENING MACHINES, Ateliers de Mecanique de Valenciennes, 27, Avenue du General Horn, Valenciennes (Nord), France.

The invention relates to a saw sharpening machine comprising a grinding wheel which is rotated about its axis and moved away from and towards the teeth of the blade. Giving the grinding wheel a planetary movement by which its axis describes an arc perpendicular to that of the blade makes it possible to approach the serrated edge of the blade laterally and to carry out



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progressive sharpening. As shown in the drawings a spindle *A* supporting a grinding wheel *B* is mounted eccentrically within a cylinder *C* and rotates on two or more ball bearings *D*. The cylinder *C* turns on bearings *E* at 30 to 100 r.p.m., whilst the grinding wheel spindle rotates at high speed. An internally toothed driving wheel *F* on the axis of the cylinder *C* meshes with an externally toothed driven wheel *G* on the grinding wheel spindle. The planetary movement of the grinding wheel *B* enables a fine finish to be obtained after sharpening, mainly due to the prolonged contact of the saw *J* and the grinding wheel.—*December* 24, 1952.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24 Victoria Street, London, S.W.1.

JIG BUSHES

No. 1098 : 1953. This is a revision of the specification originally prepared as a war emergency measure, which, as its name implied, related only to drilling jig bushes.

As was to be expected with such a fundamental production component, difficulties arose when, on attempts being made to use the bushes with reamers, it was found that the reamer would not enter the standard bush unless it were lapped beforehand. As a very large proportion of the applications were for reamering operations, the first requirement of the revision was an extension to provide suitable bores. The task, although apparently simple, soon proved to be beset with serious difficulties, and the tolerances presented in the tables of this revision, while not solving all aspects of the problems, do represent the most efficient compromise. In certain extreme cases it may not, even now, always be possible for a bore on minimum size to accept a reamer on maximum, but, if the jig bushes are to maintain their efficiency as guides over a long period, then no other tolerances than those laid down are possible.

The problem of "closing in" has been very carefully investigated. One rather surprising result of the experiments carried out was that under ordinary industrial conditions of research, the amount of "closing in" was unpredictable, a finding which had a certain amount of repercussion on the limits of tolerance in the specification. Incidentally, while "U" limits from B.S. 164, "Limits and Fits," were given in the war emergency issue, the limits for the holes for the jig plates in this revision have been changed and refer to the plates when manufactured from ferrous material.

A table given for slip renewable bushes allows certain overlapping, as in the original. Despite the fact that such a condition is undesirable from a (narrow) viewpoint, it has proved to be very necessary from the practical angle, hence its retention, but the group numbering system has been dropped as a cause of possible confusion.

The specification has been prepared with the full co-operation of the principal manufacturers of jig bushes and should, therefore, prove advantageous to planning and production departments and to any works where jigs are used in the manufacturing process. Price 3s.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on or before the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Jan. 27th.—W. MIDLANDS SECTION : Technical College, Wulfruna Street, Wolverhampton, "The Search for Bandwidth Economy in Television," D. A. Bell, 7.15 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., Feb. 2nd.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Gas Turbines and Their Applications in Iron and Steel Works," F. E. Baumann, 6.30 p.m.

ELECTRIC RAILWAY SOCIETY

Thurs., Feb. 5th.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, "The Swiss Federal Railways," C. Smith, 7.15 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Jan. 27th.—Church Institute, Albion Street, Hull, "Silicones and Their Industrial Uses," N. H. Collings, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Jan. 26th.—LEEDS CENTRE : Lighting Service Bureau, 24, Aire Street, Leeds, 1, "The Physical Principles Governing Fittings Design," W. H. Willott, 6.15 p.m.——LEICESTER CENTRE : E. Midlands Electricity Board, Charles Street, Leicester, "Automobile Lighting," K. J. Jones, 6.30 p.m.

Tues., Jan. 27th.—CARDIFF CENTRE : S. Wales Electricity Board, Cardiff, "Stagelighting," L. G. Applebee, 5.45 p.m.——LIVERPOOL CENTRE : Merseyside and N. Wales Electricity Board's Service Centre, Whitechapel, Liverpool, 1, "Black Light, its Effect and Application," H. L. Privett, 6 p.m.

Wed., Jan. 28th.—SWANSEA GROUP : Minor Hall, Y.M.C.A., Swansea, "Coloured and Directional Light as Applied to the Stage," L. G. Applebee, 6 p.m.——LONDON MEETING : Trotter-Paterson Memorial Lecture : Royal Institution, Albemarle Street, London, W.1, "The Nervous Reactions of the Retina," E. D. Adrian, 6 p.m.

Thurs., Jan. 29th.—BRADFORD GROUP : Yorkshire Electricity Board, 45–53, Sunbridge Road, Bradford, "Lighting for Celebrations," A. D. Charters, 7.30 p.m.

Fri., Jan. 30th.—BIRMINGHAM CENTRE : "Regent House," St. Philip's Place, Colmore Row, Birmingham, "Whither Lighting Design," A. J. P. Pashler and J. R. Anstey, 6 p.m.

Tues., Feb. 3rd.—STOKE-ON-TRENT GROUP : Midlands Electricity Board, 31, Kingsway, Stoke-on-Trent, "Glass in the Service of Light," A. J. Holland, 6 p.m.

Wed., Feb. 4th.—EDINBURGH CENTRE : Lighting and Cleansing Department, 357, High Street, Edinburgh, "Luminescence as Applied to Lighting," H. G. Jenkins and A. H. McKeag, 7 p.m. ——NEWCASTLE CENTRE : Minor Durrant Hall, Oxford Street, Newcastle upon Tyne, 1, "Lighting and Vision as Age Advances," H. C. Weston, 6.15 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Jan. 26th.—W. AND E. YORKS BRANCH : The University, Leeds, Film, "Basic Principles of Lubrication," 7.30 p.m.

Thurs., Jan. 29th.—S. YORKSHIRE BRANCH : Grand Hotel, Sheffield, Film, "Oxygen in Industry," and Liquid Oxygen Demonstration, 7.30 p.m.

Tues., Feb. 3rd.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "Selection, Installation and Maintenance of Small Diesel Engines," D. C. Edwards, 7 p.m.——EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, "Preventive Maintenance—the British and American Approach," T. C. Robinson, 7 p.m.——S. WALES BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, "Water Treatment," 7.15 p.m.

Wed., Feb. 4th.—SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, "Electronics in Industry," with Films, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Jan. 28th.—Waldorf Hotel, Aldwych, London, W.C.2, "Runners and Risers," Three Short Papers, E. D. Daybell, P. A. Russell and R. W. Ruddle, 7.30 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

To-day, Jan. 23rd.—Engineers' Club, Albert Square, Manchester, "The Industrial Application of Dyes," F. Parrott, 7 p.m.

INSTITUTE OF FUEL

Tues., Jan. 27th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Efficiency of Domestice Space-Heating Appliances Using Solid Fuel," L. L. Fox, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Wed., Jan. 28th.—Technical College, Gravesend, "Photo-Elasticity," J. Ward, 7 p.m.

Thurs., Jan. 29th.—Technical College, Barrow-in-Furness, "Construction of Marine Boilers," A. P. Monk, 7.30 p.m.

Tues., Feb. 3rd.—JUNIOR LECTURE : S.E. London Technical College, Lewisham Way, London, S.E.4., "Diesel-Hydraulic Propulsion, F. J. Mayor, 8 p.m.

INSTITUTE OF PETROLEUM

Wed., Jan. 28th.—26, Portland Place, London, W.1, "Geophysics—Its Problems and Trends," D. T. Germain-Jones, 5.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., Jan. 31st.—MIDLANDS BRANCH : The University, Edmund Street, Birmingham, Annual General Meeting, "The Treatment of Waste Gases in Chemical Industry," W. A. Damon.

INSTITUTION OF CIVIL ENGINEERS

To-day, Jan. 23rd.—YORKSHIRE ASSOCIATION : Great Northern Station Hotel, Leeds, "The Acomb-Naburn Sewerage Scheme, York," C. J. Minter, 7 p.m.——MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Recent Applications of Shell Concrete Construction in England and Wales," K. Hajnal Konyi, 6 p.m.

Tues., Jan. 27th.—RAILWAY MEETING : Great George Street, Westminster, London, S.W.1, "Design of Structures in Relation to Maintenance and Inspection," F. Turton and N. S. Cox, 5.30 p.m.

Tues., Feb. 3rd.—ROAD MEETING : Great George Street, Westminster, London, S.W.1, "Some Aids to Traffic Movements," R. A. B. Smith, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 26th.—RADIO SECTION : Savoy Place, London, W.C.2, Discussion on "The Relative Merits of Harmonic and Intermodulation Measurements in Assessing Distortion in Audio Equipment," opened by E. W. Berth-Jones, 5.30 p.m.

Wed., Jan. 28th.—SUPPLY SECTION : Savoy Place, London, W.C.2, "Some Researches on Circuit-Breaking by Means of High-Voltage Circuit Breakers, with Special Reference to Current-Chopping," A. F. B. Young, 5.30 p.m.

Mon., Feb. 2nd.—S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "Application of Iron-Cored Coils as Control and Circuit Elements," P. J. Hetzel ; "Arc Quenching Circuits," B. H. Stonehouse ; "Machines, Animals and Information," B. De Ferranti, 6 p.m.

Tues., Feb. 3rd.—MEASUREMENTS AND SUPPLY SECTIONS : Savoy Place, London, W.C.2, "A Moving Coil Relay Applied to Modern High-Speed Protective Systems," C. Ryder, J. Rushton and F. M. Pearce, 5.30 p.m.——N. MIDLAND CENTRE : British Electricity Authority, 1, Whitehall Road, Leeds, 1, Informal Discussion, "Electric Winders and the Supply Authority," opened by D. R. Love and L. Abram, 6.30 p.m.

Thurs., Feb. 5th.—ORDINARY MEETING : Savoy Place, London, W.C.2, "The First Stage of the Electrification of the Estrada de Ferro Santos a Jundiai (Late Sao Paulo Railway)," R. J. B. Chatterton and D. H. Rooney, 5.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., Jan. 28th.—W. OF SCOTLAND BRANCH : Engineering Centre, 351, Sauchiehall Street, Glasgow, C.2, Industrial Films, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Jan. 27th.—39, Elmbank Crescent, Glasgow, C.2, "Production of Sound Castings by Controlled Rate of Heat Transfer," B. W. Payne and C. A. Parlanti, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 23rd.—Storey's Gate, St. James's Park, London, S.W.1, Discussion on "Design of Precision Grinding Machines," G. H. Asbridge, 5.30 p.m.

Wed., Jan. 28th.—E. MIDLANDS BRANCH : Conference Room, Peterborough Generating Station, British Electricity Authority, Peterborough, "The Measurement and Interpretation of Machinery Noise, with Special Reference to Oil Engines," C. H. Bradbury, 7.30 p.m.

Fri., Jan. 30th.—Storey's Gate, St. James's Park, London, S.W.1, Discussion on "Scale Formation in Sea-Water Distilling Plants and its Prevention," H. Hillier, 5.30 p.m.

INSTITUTION OF MINING ENGINEERS

Thurs., Jan. 29th.—Connaught Rooms, Great Queen Street, London, W.C.2, Annual General Meeting, 11.15 a.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Jan. 27th.—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Coaxial Cables—Some Practical Aspects of Their Design and Maintenance," G. E. Rossiter, 5 p.m.

Wed., Feb. 4th.—Conference Room, 4th Floor, Waterloo Bridge House, London, S.E.1, "Methods of Investigation in the Telephone Branch Circuit Laboratory," M. Mitchell, 5 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 2nd.—N.E. SECTION : Neville Hall, The Mining Institute, Neville Street, Newcastle upon Tyne, "The Neoprene Lattices—Their General Characteristics, Compounding and Processing," W. G. Vennells, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Jan. 23rd.—MIDLAND COUNTIES BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, "Recent Applications of Shell Concrete Construction in England and Wales," K. Hajnal-Konyi, 6 p.m.——S.W. COUNTIES BRANCH : Duke of Cornwall Hotel, Mill Bay, Plymouth, "Construction of Two Power Stations in the South-West," Leslie Richardson, 7 p.m.

Tues., Jan. 27th.—LONDON GRADUATES' AND STUDENTS' SECTION : 11, Upper Belgrave Street, London, S.W.1, Address by the President, 5.55 p.m.

Wed., Jan. 28th.—LANCASHIRE AND CHESHIRE BRANCH : Reynolds Hall, College of Technology, Manchester, "The Structural Design of the Mediæval Cathedral," Ronald Oates, 6.30 p.m.

Fri., Jan. 30th.—MIDLAND COUNTIES BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, "Further Recent Midland Structures," 7 p.m.

Tues., Feb. 3rd.—NORTHERN COUNTIES BRANCH : Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Electricity Generating Stations," B. A. E. Hiley, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 23rd.—Townsend House, Greycoat Place, London, S.W.1, "Cathodic Protection," W. Godfrey Waite, 7 p.m.

Sat., Jan. 24th.—N.W. SECTION : Geographical Society, 16, St. Mary's Parsonage, Manchester, "Hydro-Electric Schemes," F. Burgess, 2.30 p.m.

Fri., Jan. 30th.—Townsend House, Greycoat Place, London, S.W.1, "Metal Spinning," R. E. Baskerville, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Jan. 23rd.—Engineers' Club, Albert Square, Manchester, "Production of Modern Design Cars," E. W. Hancock, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 30th.—Bolbec Hall, Newcastle upon Tyne, 1, "Thickness of Tubes for Water-tube Boilers," D. W. Crancher, 6.15 p.m.

PURCHASING OFFICERS ASSOCIATION

Tues., Feb. 3rd.—OXFORD AND BUCKS GROUP : Red Lion Hotel, High Wycombe, Film Show, "Steel Industry," 7.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Jan. 27th.—GRADUATES' AND STUDENTS' SECTION : 4, Hamilton Place, London, W.1, "A Physical Interpretation of Supersonic Flow," R. Stanton Jones, 7.30 p.m.

Thurs., Jan. 29th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Titanium—A Survey," P. L. Teed, 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Jan. 27th.—Manson House, Portland Place, London, W.1, "Instrumentation in the Paper-Making Industry," F. W. Hayward, 6.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Jan. 28th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "The Projection of Microscopic Structures," W. J. Garnett, 6.30 p.m.